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DIGITAL COMPUTER PROGRAM DF1758
FULLY COUPLED NATURAL FREQUENCIES
AND MODE SHAPES OF A HELICOPTER
ROTOR BLADE

by R. L. Bennett

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TABLE OF CONTENTS

I. INTRODUCTION

This report describes the analytical techniques and computer program developed in the fully-coupled rotor vibration study.

The rotor blade natural frequency and mode shape analysis is implemented in a digital computer program designated DF1758.

The program computes collective, cyclic, and scissor modes for a single blade within a specified range of frequency for specified values of rotor RPM and collective angle.

The analysis includes effects of blade twist, cg offset from reference axis, and shear center offset from reference axis. Coupled inplane, out-of-plane, and torsional vibrations are considered. Normalized displacements, shear forces and moments may be printed out and Calcomp plots of natural frequencies as a function of rotor RPM may be produced.

The analysis of this report was taken from "Natural Modes of a Helicopter Blade", an unpublished report by the late N. O. Myklestad, Professor of Mechanical Engineering at the University of Texas at Arlington.

This documentation is a revision of the original document by R. J. Brumbaugh (BHC Report 299-099-491).

II. ANALYSIS

A. The Physical Blade System:

A sketch of the typical blade system and the axis system is shown in Figure 1. The blade system is divided into two major parts, the hub portion and the blade portion. The hub portion is unaffected by collective angle changes.

Both the hub and blade are divided into a suitable number of sections (20 total) which need not be of equal length. A sketch of one section and its orientation to the blade axis system is shown in Figure 2. The point where two sections meet is referred to as a station.

Three sets of boundary conditions of the blade system at the axis of rotation are considered. The collective mode boundary conditions are those of a hinged attachment with axis of rotation about the Y axis; the cyclic mode, of a hinge with its axis on the X-axis; and the scissors mode, of rigid attachment. In all three mode types, rotation of the blade about the Z axis is constrained by the control system.

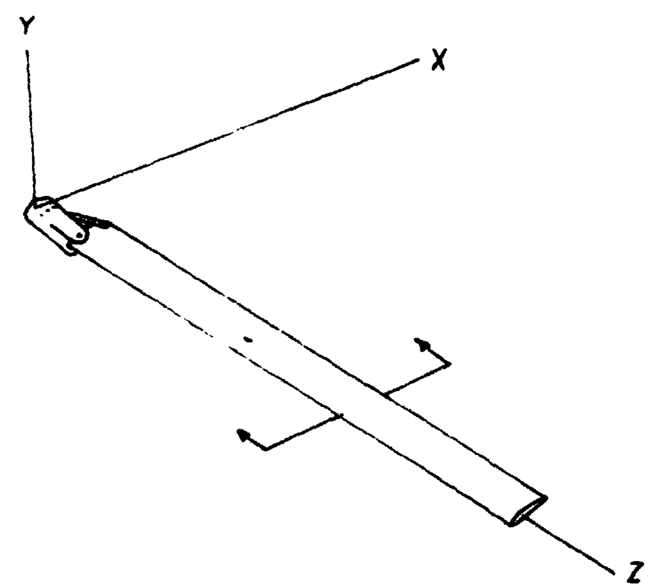


Fig. 1
Axis System

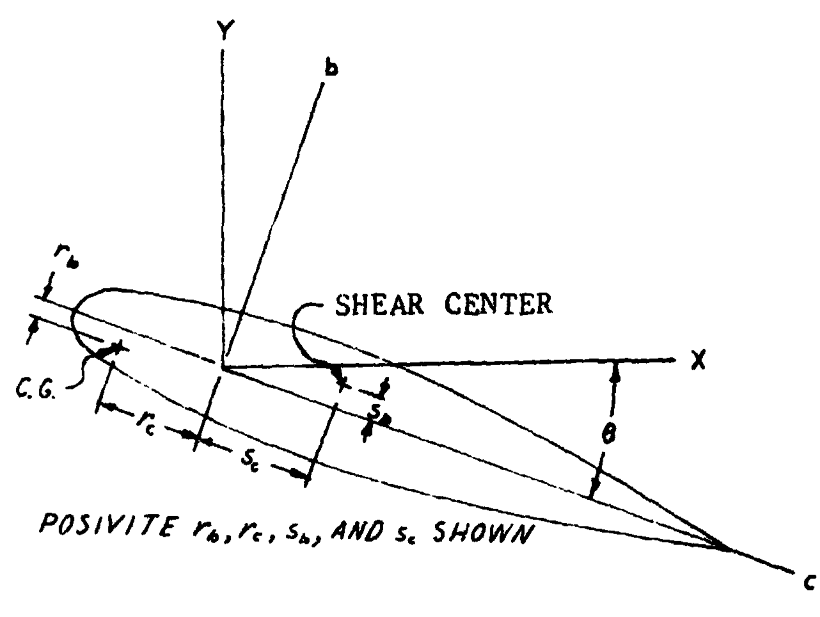


Fig. 2
Blade Cross
Section

B. Approximations to the Blade System.

The following physical properties of each section are approximated as being constant over the section:

$\bar{\rho}$ - Weight per inch of section

r_b, r_c - Cross section cg offset from Z axis (Fig. 2)

s_b, s_c - Shear center offset from Z axis (Fig. 2)

θ - Angle of twist between C, B, Z axis system and X, Y, Z axis system. (The θ of a section is calculated as the average of the θ's of the stations at each end.)

EI_b - Beamwise bending stiffness

EI_c - Chordwise bending stiffness

GJ - Torsional stiffness

$I_{bb} = \int \rho b^2 dA$ (over the cross sectional area)

$I_{cc} = \int \rho c^2 dA$

The control system restraint on blade rotation about the Z axis is approximated by a torsional spring constant acting at the origin.

C. The Mathematical Model

1. Calculation of natural frequencies

One-half of each section's mass and inertial properties is concentrated at each end of the section. Each section is then a massless elastic structure and each station has one-half the mass and inertial properties from the section on each side of it.

Deflections, moments, and shear forces at the inboard end of a section are calculated from the deflections, moments and shear forces at the outboard end (see Appendix A). All deflections, moments, and shear forces are calculated as coefficients times the deflections at the tip of the blade, finally resulting in the deflections, moments, and shear forces at the origin. The boundary conditions are then calculated as a function of the tip deflections leading to the equation: (See Page 43).

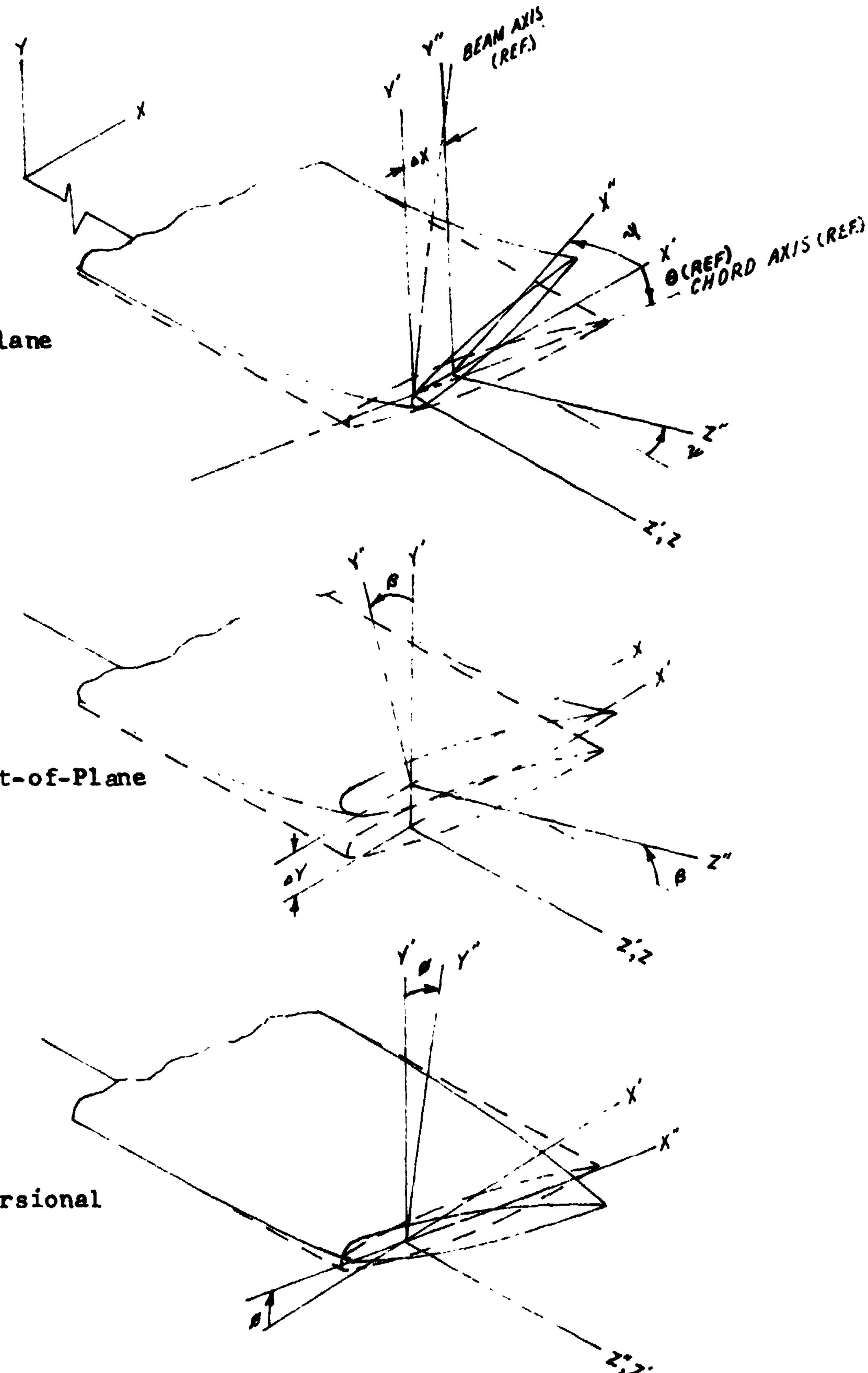
$$\lfloor C\ (\omega) \rceil \begin{bmatrix} \Delta y_{tip} \\ \psi_{tip} \\ \Delta x_{tip} \\ \beta_{tip} \\ \phi_{tip} \end{bmatrix} = \{0\}$$

where ω is the frequency of vibration, deflections are as shown in Figure 3, and C (ω) is a 5x5 matrix (4x4 if torsion is ignored).

The natural frequencies are those values of ω that satisfy the boundary equations i.e. for which the determinant of $|C|$ is equal to zero.

The natural frequencies are found by calculating $|C|$ at even increments of ω over the frequency range of interest. If the determinant of $|C(\omega_k)|$ has a different sign than the determinant of $\lfloor C(\omega_k + \Delta\omega) \rceil$, then a natural frequency is between ω_k and $\omega_k + \Delta\omega$, and a parabolic iteration scheme is used to converge to the natural frequency.

If two natural frequencies lie between the sample frequencies then no sign change will occur, so if any three consecutive determinants have the same sign and the absolute value of the middle determinant is the smallest of the three, then smaller frequency increments are taken in this range to bracket two roots.



3a: Inplane

3b: Out-of-Plane

3c: Torsional

Fig. 3 DISPLACEMENTS

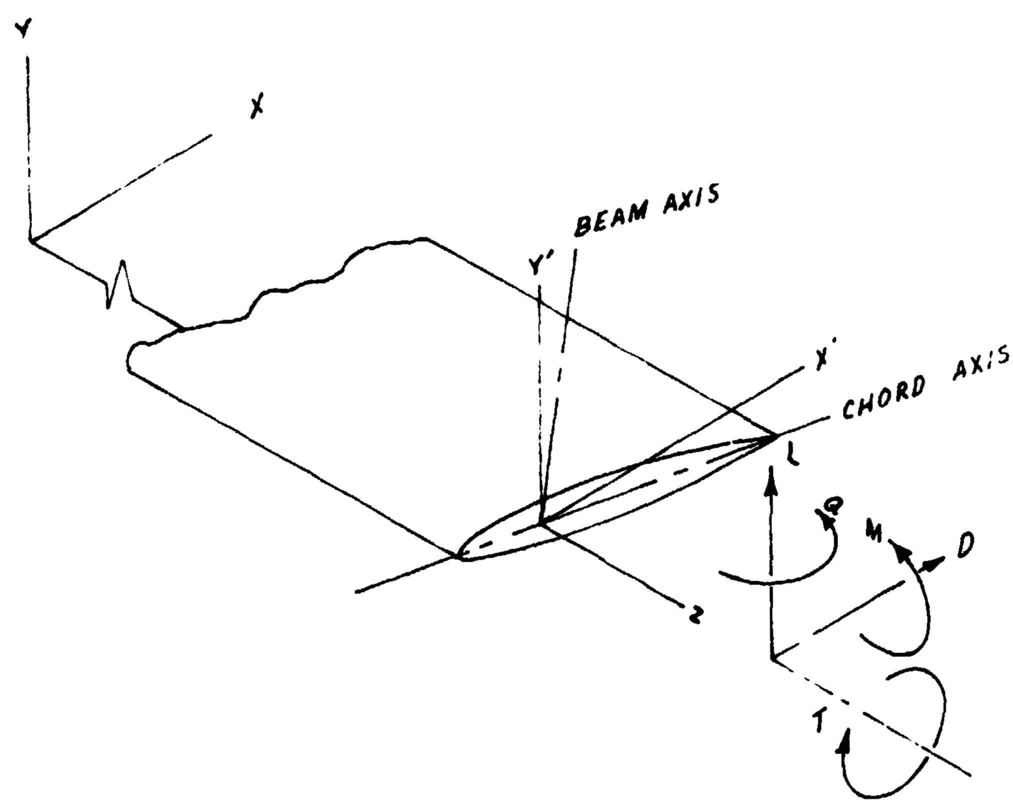


Fig. 4 FORCES AND MOMENTS ON OUTBOARD END OF SEGMENT

2. Boundary Conditions

The boundary conditions used in calculating the blade natural frequencies are as follows:

Mode Type	Out-of-Plane Boundary Condition	Inplane Boundary Condition
Collective	$\beta(0) = 0$	$Q(0) = 0$
	$Y(0) = \dfrac{L(0)}{\dfrac{20*10^6}{R*VSOFT} - \dfrac{VMASS*NB}{386.4}\,\omega^2}$	$x(0) = 0$
Cyclic	$M(0) - k_\beta \beta(0) = 0$	$\psi(0) = 0$
	$y(0) = 0$	$x(0) = \dfrac{D(0)}{\dfrac{20X10^6}{R*HSOFT} - \dfrac{HMASS*NB}{286.4}\,\omega^2}$
Scissor	$\beta(0) = 0$	$x(0) = 0$
	$y(0) = 0$	$\psi(0) = 0$

The functional notation designates the radial location at which the boundary condition is applied.

The quantities VSOFT, VMASS, HSOFT, HMASS can be obtained from the rotor support system shown in Figures 4a and 4b by the following equations:

$$VSOFT = \frac{20*10^6}{R*k_{op}}$$

$$VMASS = \frac{M_{HUB,\ o.p.}}{NB}$$

$$HSOFT = \frac{20*10^6}{R*k_{op}}$$

$$HMASS = \frac{M_{HUB,\ i.p.}}{NB}$$

where VSOFT is the out-of-plane restraint elasticity

VMASS is the effective hub mass in the out-of-plane direction per blade

HSOFT is the inplane restraint elasticity

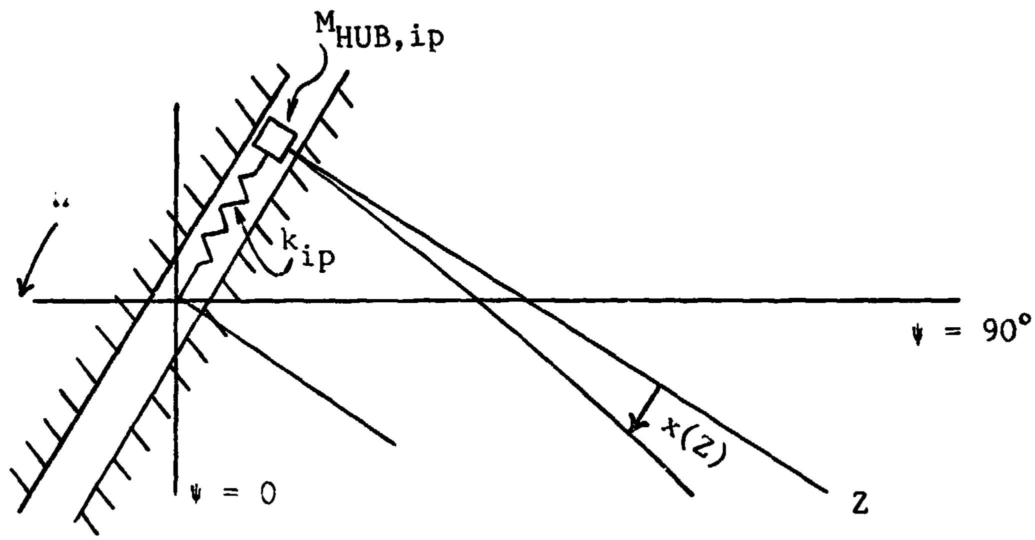


Figure 4a. Inplane Hub Restraint.

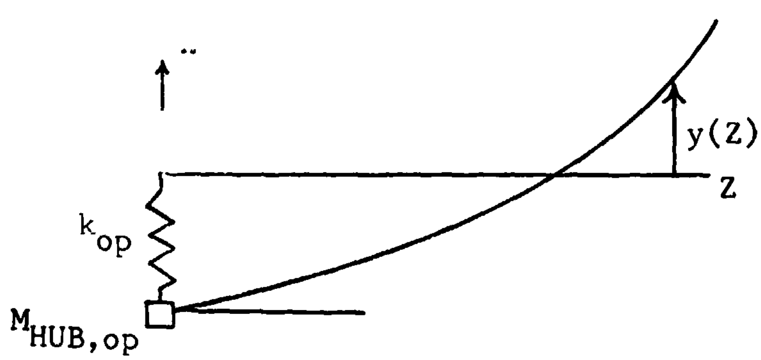


Figure 4b. Out-of-Plane Hub Restraint.

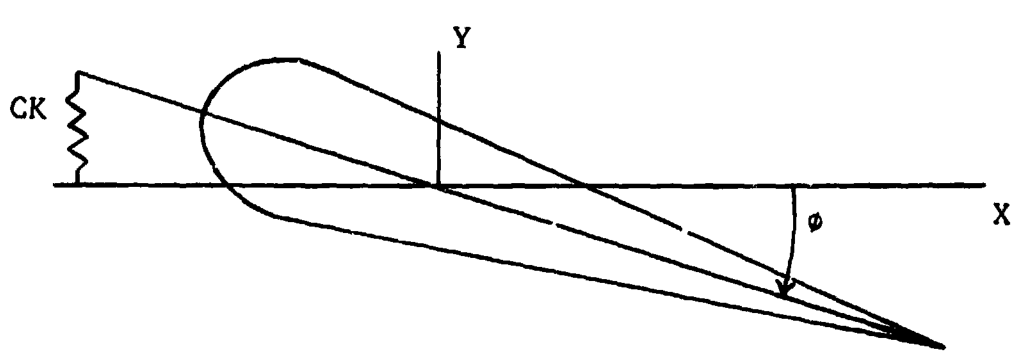


Figure 4c. Torsion Restraint.

HMASS is the effective hub mass in the inplane direction per blade

R is the blade radius (in)

NB is the number of blades

k_{op} is the apparent spring rate of the out-of-plane support system (lb_f/in)

$M_{HUB,op}$ is the apparent mass of the out-of-plane support system (lb_m)

k_{ip} is the apparent spring rate of the inplane support system as seen in the rotating coordinate system (lb_f/in)

$M_{HUB,ip}$ is the apparent mass of the inplane support system as seen in the rotating coordinate system (lb_m)

k_β is the blade flapping spring per blade (ft-lb_f/deg).

The torsional boundary condition for all modes is

$$\phi(\text{PHOFF}) = \frac{T(\text{PHOFF})}{CK}$$

where CK is the control system stiffness.

3. Calculation of Mode Shapes

Assuming that:

$\Delta y = 1.$

and using 4 (3 if torsion is ignored) of the boundary condition equations, the tip deflections are calculated. Since all deflections, moments and forces are already known as functions of the deflections, the mode shapes can then be calculated. The mode shapes are then normalized to the largest linear deflection or 10 deg. twist.

Since completely uncoupled modes often result in the above set of equations producing a near singular matrix, mode shape calculations for uncoupled modes may be inaccurate. Uncoupled modes result from input of untwisted blade at 0 deg. root collective with no cg or shear center offset. If the program option to add uncoupled modes to plot is used the program actually calculates for a case with very small coupling compared to original case (twist angle divided by 1000, etc.)

III. COMPUTER PROGRAM DF1758

A. Program Description

The natural frequencies and mode shapes of a blade are found within a specified range of frequency and for specified ranges of rotor RPM and root collective angle. Rotor RPM and root collective angle are taken at even increments between a minimum and a maximum value. Torsional terms may be calculated or ignored.

A listing of program DF1758 is in Appendix D. A brief description of its function appears at the start of the listing of each subroutine. In addition the following system subroutines and Calcomp subroutines are called.

System Subroutines:

DATE (ndate)

ndate - 8 byte variable returned as date in form "01/02/71" (2 Jan 71).

SETIME (time)

time - Initializes TIMEX to "time" in minutes.

TIMEX (tu,dt,tl)

tu - Time (in min.) since call to SETIME

dt - Time (in min.) since last call to TIMEX OR SETIME

tl = "time" - "tu"

B. Input Format

Card No.	Columns		Description	Units	Name-List
1			"Return to" Card		
2			Logic Controls		
			Starting in Columns 1, 11, 21, 31, etc.		
		Control	Words		
		DECK	Read full data deck (excluding torsion + twist inputs)		
		NAMELIST	Read changes to previous case		
		PUNCH	Punch Aeroelastic data for input to C81		
		MODES	Print mode shapes at one combination of rpm and collective pitch		
		ALLMODES	Print all calculated mode shapes. MODES must be used		
		PLOT	Make fan plots on CALCOMP		
		DYN5	Punch modes for DYN5 (not available at LRC)		
		TORSION	Read and use torsion data		
		TWIST	Read nonlinear twist distribution		
		END	End Problem		
3	5-10		Problem Identification Number	NAME	
	31-67		Problem Identification	ITLE	

Card No.	Columns	Description	Units	Name-List
4	1-10	Number of Non-Feathering Hub Segments	CYCLE	
	11-20	Effective Torsional spring rate of drive system per blade	$\left(\frac{\text{in-lb}}{\text{rad}}\right)$	TORSO
	21-30	Effective vertical hub mass per blade	(lb_m)	VMASS
	31-40	Effective inplane hub mass per blade	(lb_m)	HMASS
	41-50	Effective vertical restraint/10^6	$\left(\frac{1}{\text{lb}_f}\right)$	VSOFT
	51-60	Effective inplane restraint/10^6	$\left(\frac{1}{\text{lb}_f}\right)$	HSOFT
	61-70	Flapping spring rate per blade	$\left(\frac{\text{ft-lb}_f}{\text{deg}}\right)$	RSOFT
5	1-5	Segment Length (0.0 for unequal)	(in)	AZBAR
	6-10	Initial rpm (omit RPM B + RPMC if only one RPM desired)	(rpm)	RPMA
	11-15	Intermediate rpm; internally set to .5*(RPMA + RPMC)	(rpm)	RPMB
	16-20	Final rpm	(rpm)	RPMC
	21-25	Initial Root Collective	(deg)	COLLA
	26-30	Intermediate Collective internally set to .5*(COLLA + COLLC)	(deg)	COLLB
	31-35	Final Collective	(deg)	COLLC
	36-40	Rotor linear twist, washout negative	(deg)	TWIST
	41-45	Number of Blades		BLADES
	46-50	Chord	(in)	

Card No.	Columns	Description	Units	Name-List
	51-55	Initial frequency in sweep [Default value = .1*RPMA]	(/rev)	PSQR
	56-60	Delta frequency in sweep [Default value = 10* max (RPMA, RPMB, RPMC)]	(/rev)	DP
	61-65	Final frequency in sweep [Default value = 40*DP]		PLAST
6	1-5	Lead-lag hinge offset	(in)	CHOFF
	6-10	Flapping hinge offset	(in)	FHOFF
	11-15	Lead-lag spring rate	(ft-lbs/deg)	SPRLG
	16-20	Pitch horn radial attachment point	(in)	PHOFF
6A 6B 6C	Optional:	Unequal segment, representation If AZBAR = 0.0, read 20 values of the radial distance to the outboard edges. Blade station locations. 7F10.0	(in)	Z
7		Beamwise stiffness x 10^{-6}	(in^2-lb_f)	EIB
	1-10	Blank		
	11-21	EIB(1) root segment		
	:	:		
	61-70	EIB(6)		
8	1-10	EIB(7)	(in^2-lb_f)	EIB
	:	:		
	61-70	EIB(13)		
9	1-10	EIB(14)	(in^2-lb_f)	EIB
	:	:		

Card No.	Columns	Description	Units	Name-List
	61-70	EIB(20) tip segment		
10		Chordwise stiffness X10^{-6}	(in^2-lb_f)	EIC
	1-10	blank		
	11-21	EIC (1) root segment		
	:	:		
	61-70	EIC (6)		
11	1-10	EIC (7)	($in^2 lb_f$)	EIC
	:	:		
	61-70	EIC (13)		
12	1-10	EIC (14)	(in^2-lb_f)	EIC
	:			
	61-70	EIC (20) tip segment		
13		Blade mass distribution		
	1-10	WTPL(1) root segment	(lb_m/in)	WTPL
	:	:		
	61-70	WTPL(7)		
14	1-10	WTPL(8)	(lb_m/in)	WTPL
	:	:		

Card No.	Columns		Description	Units	Name-List
	61-70		WTPL(14)		
15	1-10		WTPL(15)	(lb_m/in)	WTPL
	:		:		
	51-60		WTPL(20) tip segment	(lb_m/in)	
	61-70		Tip weight	(lb_m)	WTPL(21)
16			Blank card		
16A		Optional:	Nonlinear twist distribution	(deg)	THD
16B 16C			If TWIST was on Card 2, read 21 values of TWIST, root to tip. Note that this includes all stations including the zero radius point, 7F10.0 (7 per card in 10-column fields)		
		Optional:	If TORSION was included on Card 2, read 22 additional data cards.		
17	11-20		Control system spring rate	(in-lb_f/rad)	CK
18-20			20 values of beamwise mass moments of inertia (I_{bb}) 7F10.0	(in-lb_f-sec^2)	EYEB
21-23			20 values of chordwise mass moments of inertia (I_{cc}) 7F10.0	(in-lb_f-sec^2)	EYEC
			Note: Normally EYEB<<EYEC		
24-26			20 values of blade torsional rigidity * 10^{-6} 7F10.0	(lb_f-in^2)	GI
27-29			20 values Beamwise offset of shear center (+ up) 7F10.0	(in)	SB

Card No.	Columns	Description	Units	Name-List
30-32		20 values Chordwise offset of shear center (+ aft) 7F10.0	(in)	SC
33-35		20 values Beamwise offset of cg (+ down) 7F10.0 (Col. 61-70, Card 35 is tip weight offset)	(in)	RB
36-38		20 values Chordwise offset of cg (+ forward) 7F10.0 (Col. 61-70 Card 38 is tip weight offset)	(in)	RC

NOTES CONCERNING INPUT FORMAT:

1. The punched output for C81 is distributed over 20 equal segments even if unequal segment data is input to the program and used in the calculations.

2. All stiffness values (EIB, EIC, GI) input under the DECK option are multiplied by 10^6 prior to use. Stiffness values input under NAMELIST are not modified.

3. Provision is made to handle one beamwise and/or one chordwise segment with zero stiffness as a pinned joint. This gives a more accurate model of an articulated rotor than the hinge offsets if the unequal segment option is used with a short segment for the hinge.

4. For use in C-81 shear center & c.g offset must be calculated w.r.t. 1/4 chord.

C. Output Format

1. A summary of all input is printed out.

2. If input requested printout of mode shapes, then one page is printed for each natural frequency. Normalized values are printed for deflections in the x-y plane, shear forces and moments in the beamchord plane, and for torsional displacements and moments if torsion is used.

3. A summary of all natural frequencies is printed.

4. If input requested a plot, then natural frequency is plotted as a function of rotor RPM. The fan plots also show the forcing function frequencies as a function of hub type and number of blades.

The maximum deflection plane angle shown on output is the arctan of $\Delta y/\Delta x$ where $\Delta x^2+\Delta y^2$ is at maximum value.

See Appendix B for sample of output.

5. If the input data requests the output to be punched out, the following cards are produced:

CARD	DESCRIPTION	FORMAT
1	Identification Card (Same as input Card 3)	
2-4	Blade Mass Distribution and Tip Weight	7F10.0
5-7	Beamwise Mass Moments of Inertia	7F10.0
8-10	Chordwise Mass Moments of Inertia	7F10.0
Up to	6 Collective Blade Modes (13 cards/mode)	6F10.0
Up to	6 Cyclic Blade Modes (13 cards/mode)	6F10.0
Up to	6 Scissor Blade Modes (13 cards/mode)	6F10.0
	6 Cyclic Detuning Cards for Collective Modes	6F10.0, 2F5.0
	6 Cyclic Detuning Cards for Cyclic Modes	6F10.0, 2F5.0
	6 Cyclic Detuning Cards for Scissor Modes	6F10.0, 2F5.0

The format for each of the first 10 cards for each blade mode is as follows:

Column	1-10	$(\text{Out-of-plane})_i$
	11-20	$(\text{Inplane})_i$
	21-30	$(\text{Torsion})_i$
	31-40	$(\text{Out-of-Plane})_{i+1}$
	41-50	$(\text{Inplane})_{i+1}$
	51-60	$(\text{Torsion})_{i+1}$

The 11th card is

Column	1-10	$(\text{Out-of-Plane})_{tip}$
	11-20	$(\text{Inplane})_{tip}$
	21-30	$(\text{Torsion})_{tip}$
	31-40	(Natural Frequency/RPM)
	41-50	(Mode Type Indicator)
	51-60	(Damping Factor)

The damping factor is set to zero for the rigid body flapping mode and 0.02 for all other modes.

The 12th card has only one value at present

Column	1-10	The change in inplane slope across an element with zero chordwise stiffness.

The 13th card will be blank. It may be replaced by the appropriate "cyclic detuning" card.

The first 12 cards contain the following additional information for identification purposes:

Column	61-66	NAME as input on Card 3
	67-68	Mode number of this mode type (1 to 6)
	69-71	Mode type indicator 1 for collective modes -1 for cyclic modes 0 for scissor modes

72-75	Value of root collective pitch
76-80	Value of rotor RPM

The "cyclic detuning" cards at the end of the mode shapes have the following format:

Columns 1-10	Natural frequency at low RPM and low pitch angle (cpm)
11-20	Natural frequency at low RPM and high pitch angle (cpm)
21-30	Natural frequency at high RPM and low pitch angle (cpm)
31-40	Natural frequency at high RPM and high pitch angle (cpm)
41-50	1/2 (high pitch angle - low pitch angle)
51-60	1/2 (high RPM - low RPM)
61-65	Average collective pitch
66-70	Average RPM
71-76	NAME from input card 3
77-78	Mode number
79-80	Mode type indicator

The transfer term, ρRC^2 is added to chordwise mass moment of inertia, I_{cc}, before the inertia is punched out.

The mode shape components have the following units

Component	Units
inplane	feet
out-of-plane	feet
torsion	degrees

If unequal segment lengths are used, the following changes are made to the punched output.

1. The mass and inertias are recomputed to be represented with 20 equal segments.

2. Linear interpolation is used to obtain mode shapes corresponding to 20 equal segments.

APPENDIX A

CALCULATION OF DEFLECTIONS, SHEAR FORCES, AND MOMENTS

A. Elastic Coefficients

1. Definitions:

d_{FB} = Beamwise deflection of elastic axis due to unit force

d_{FC} = Chordwise deflection due to unit force

d_{MB}, d_{MC} = Deflection due to unit moment

ν_{FB}, ν_{FC} = Angular deflection due to unit force

ν_{MB}, ν_{MC} = Angular deflection due to unit moment

W_T = Angle of twist due to unit torque

W_F = Angle of twist due to unit force

$\bar{z}$ = Segment length

2. Beam-Chord Axis Elastic Coefficients

$\nu_M = \bar{z}/EI$

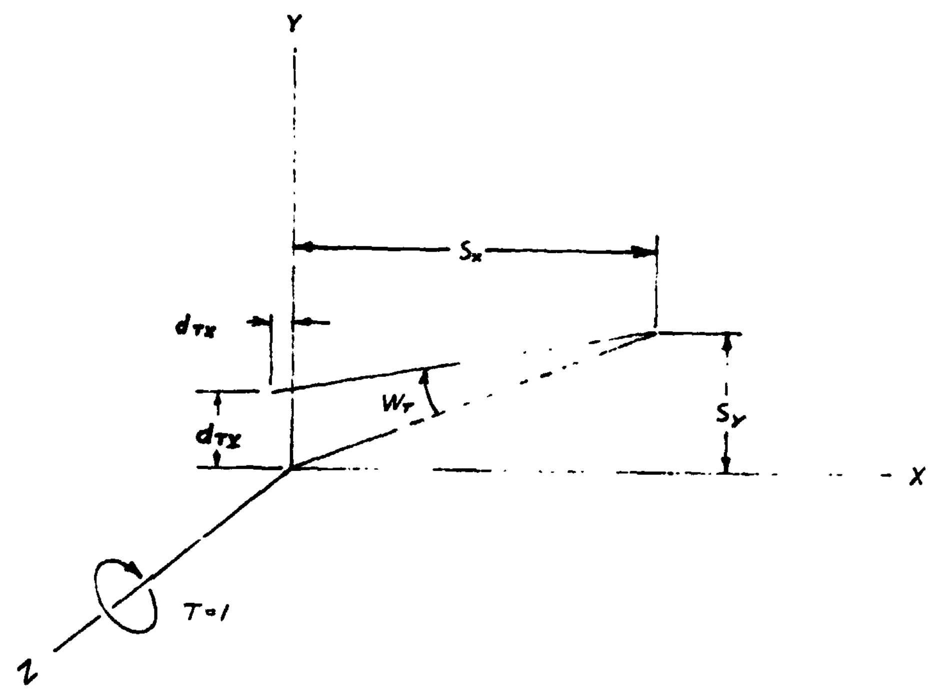
$d_M = \nu_F = \bar{z}^2/2EI$

$d_F = \bar{z}^3/3EI$

$w_T = \bar{z}/GJ$

3. X-Y-Z Axis Coefficients

The elastic coefficients are taken from Fig. 10 through Fig. 17.



$$d_{TX} = -S_y W_T$$

$$d_{TY} = S_x W_T$$

Figure 10. Linear Deflections Due to Unit Torque.

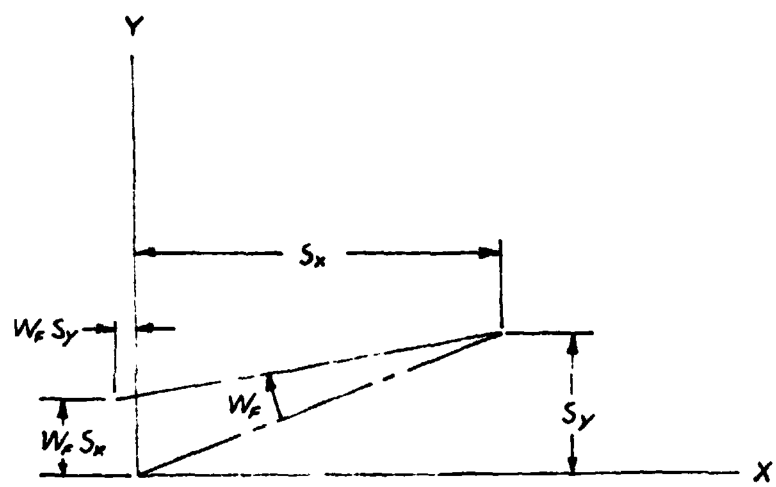
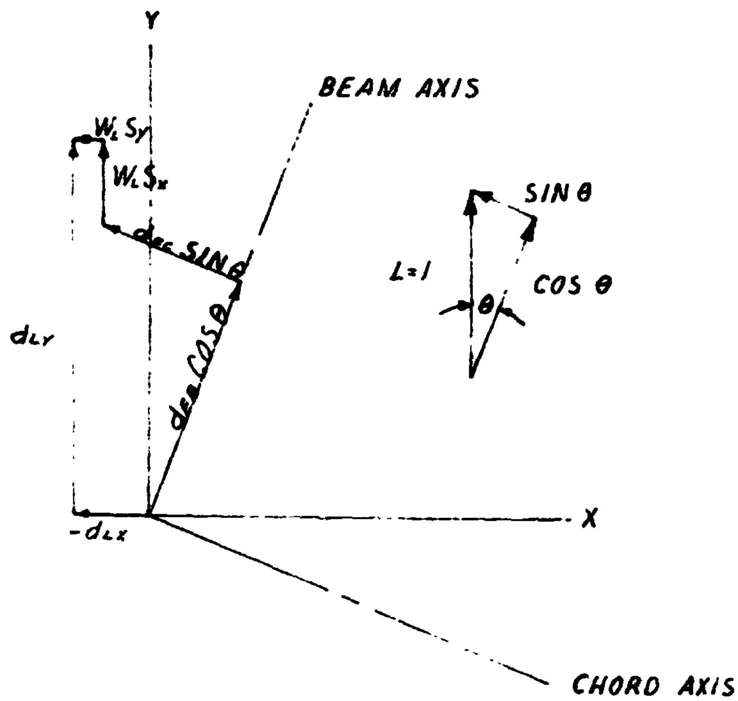


Figure 11. Linear Deflection Due to Twist Caused by Unit Force.



$$W_L = S_x W_T = d_{TY}$$

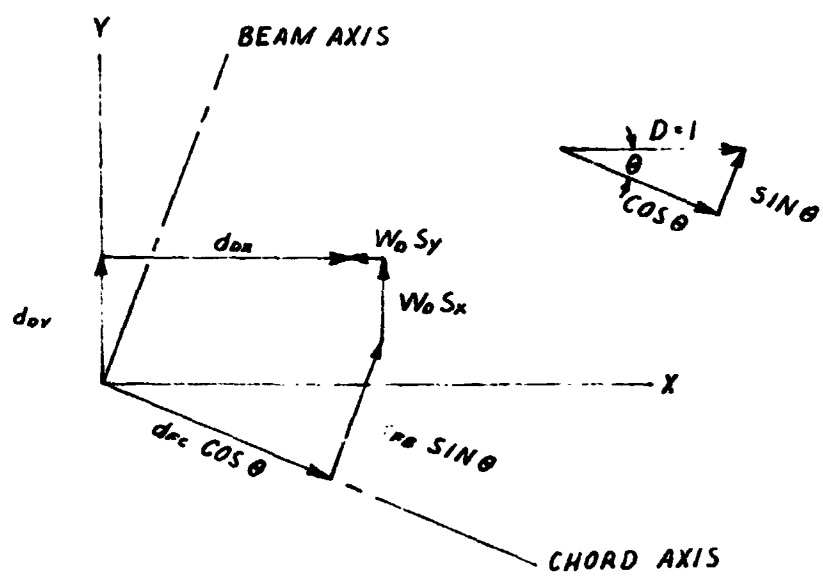
$$d_{LX} = \left(d_{FB} - d_{FC}\right) \text{SIN } \theta \text{ COS } \theta - S_y d_{TY}$$

Let: $d_{BC} = \left(d_{FB} - d_{FC}\right) \text{SIN } \theta \text{ COS } \theta$

$$d_{LX} = d_{BC} - S_y d_{TY}$$

$$d_{LY} = d_{FB} \text{ COS}^2 \theta + d_{FC} \text{ SIN}^2 \theta + S_x d_{TY}$$

Figure 12. Linear Deflections Due to Unit Out-of-Plane Force.

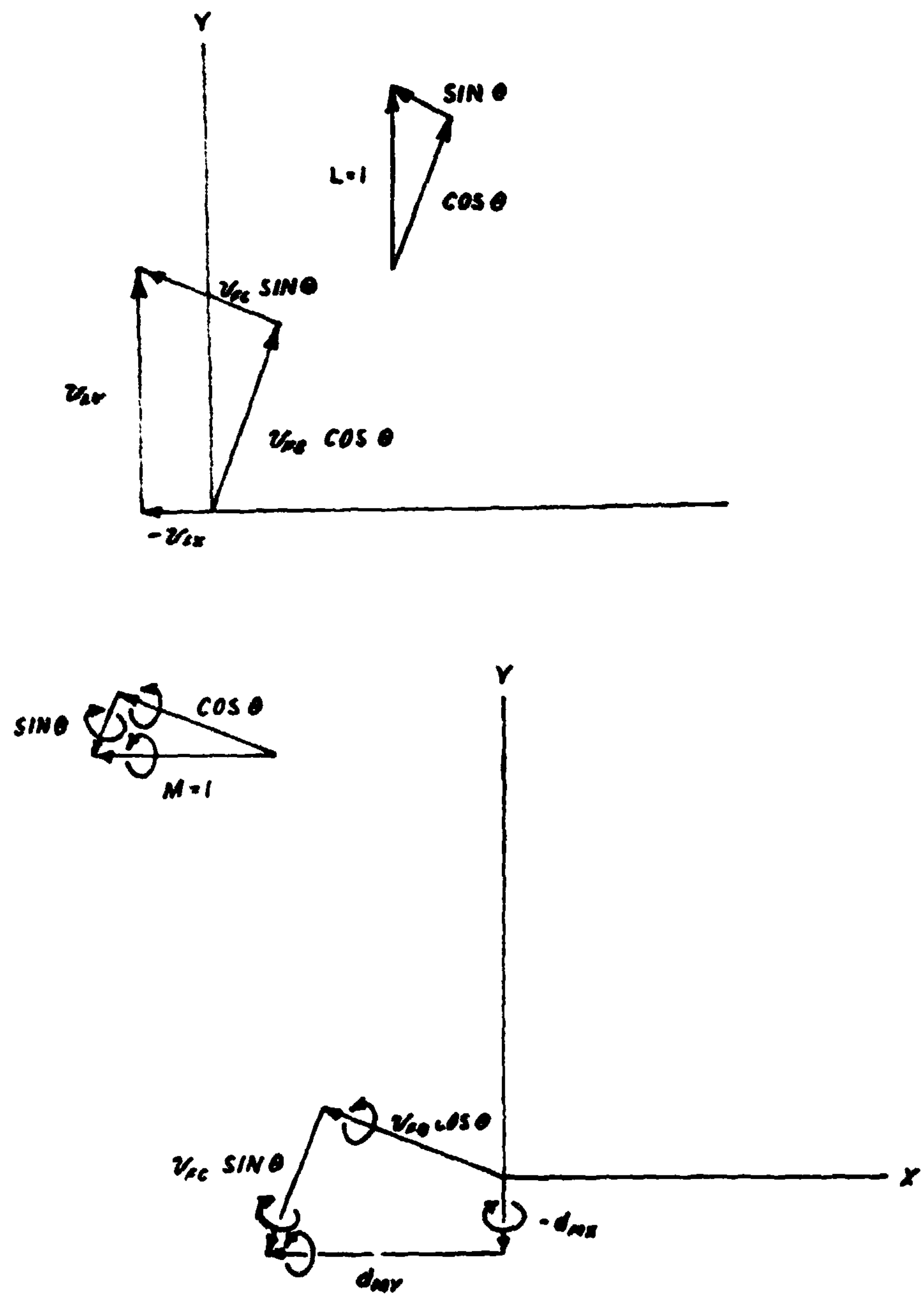


$$W_D = - S_y W_T = d_{TX}$$

$$d_{DX} = d_{FB} SIN^2 \theta + d_{FC} COS^2 \theta - S_y d_{TX}$$

$$d_{DY} = d_{BC} - S_x S_y W_T = d_{LX}$$

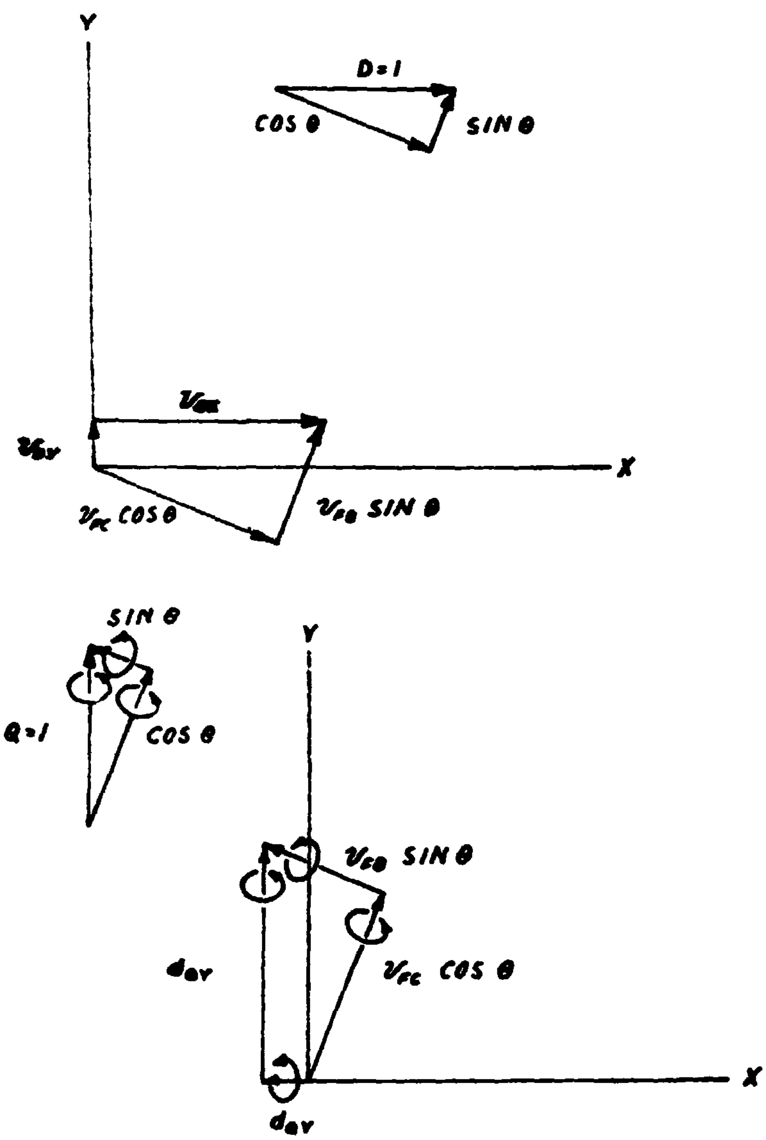
Figure 13. Linear Deflections Due to Inplane Unit Force.



$$d_{MX} = \nu_{LX} = \left(\nu_{FB} - \nu_{FC}\right) \text{SIN } \theta \text{ COS } \theta$$

$$d_{MY} = \nu_{LY} = \nu_{FB} \text{ COS}^2 \theta + \nu_{FC} \text{ SIN}^2 \theta$$

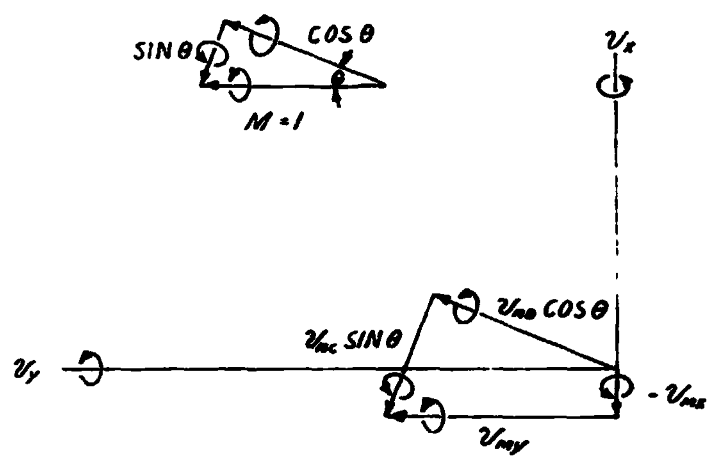
Fig. 14. Angular Deflection Due to Out-of-Plane Unit Force and Linear Deflection Due to Out-of-Plane Unit Moment.



$$d_{QX} = \nu_{DX} = \nu_{FB}\mathrm{SIN}^2\theta + \nu_{FC}\mathrm{COS}^2\theta$$

$$d_{QY} = \nu_{DY} = \left(\nu_{FB} - \nu_{FC}\right)\ \mathrm{SIN}\,\theta\,\mathrm{COS}\,\theta = \nu_{LX}$$

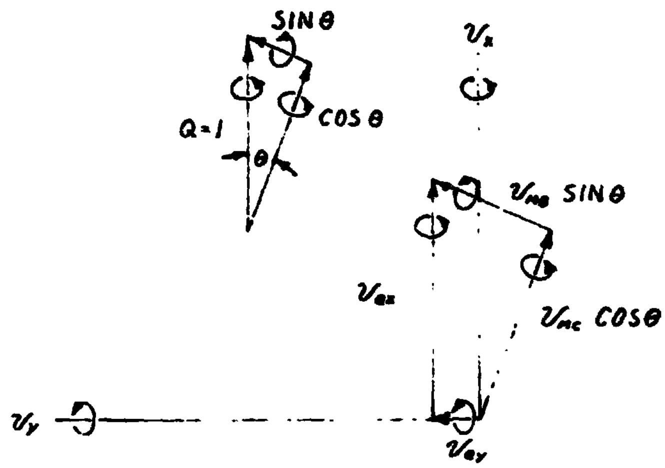
Figure 15. Angular Deflection Due to Inplane Unit Force and Linear Deflection Due to Inplane Unit Moment.



$$\nu_{MX} = \left(\nu_{MB} - \nu_{MC}\right) \mathrm{SIN}\,\theta\,\mathrm{COS}\,\theta$$

$$\nu_{MY} = \nu_{MB}\,\mathrm{COS}^2\,\theta + \nu_{MC}\,\mathrm{SIN}^2\,\theta$$

Figure 16. Angular Deflection Due to Out-of-Plane Unit Moment.



$$\nu_{QX} = \nu_{MB}\ \mathrm{SIN}^2\,\theta + \nu_{MC}\ \mathrm{COS}^2\,\theta$$

$$\nu_{QY} = \left(\nu_{MB} - \nu_{MC}\right)\ \mathrm{SIN}\,\theta\,\mathrm{COS}\,\theta = \nu_{MX}$$

Figure 17. Angular Deflection Due to Inplane Unit Moment.

B. Dynamically Equivalent Mass System

Figure 18 shows the location of mass, m_i, with respect to the coordinate system of Figure 1. The x"-y"-z" axis system is parallel to the beam-chord axis system with its origin at the c.g. I_{CC}, I_{BB}, and I_{ZZ} are second products of the mass with respect to the y"-z", x"-z", and x"-y" planes, respectively.

The masses, m_X, m_Y, and m_Z and the offsets, a_X, a_Y, and a_Z, form a dynamically equivalent mass system when:

$$2m_X + 2m_Y + 2m_Z = m_i$$

$$2a_X^2 m_X = I_{CC}$$

$$2a_Y^2 m_Y = I_{BB}$$

$$2a_Z^2 m_Z = I_{ZZ}$$

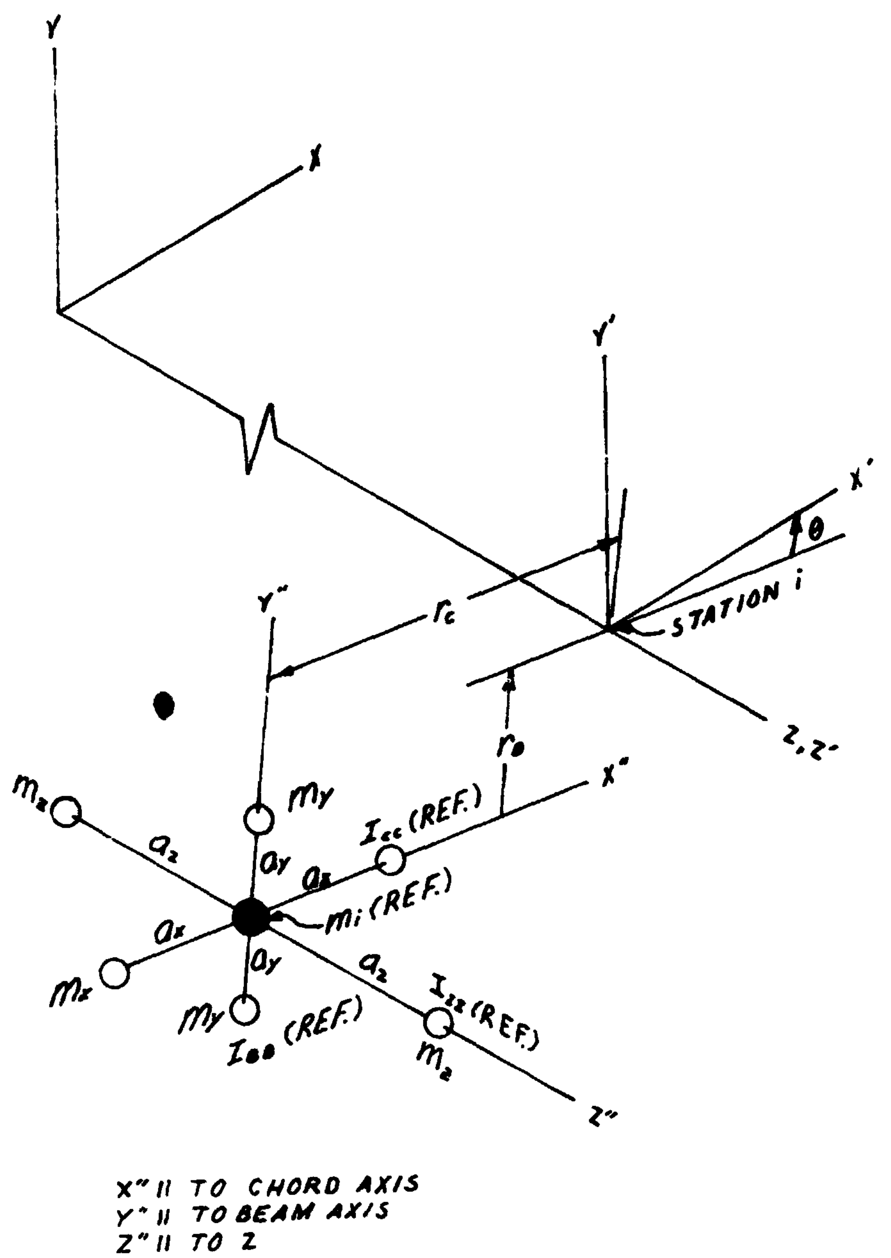


Figure 18. Dynamically Equivalent Mass System.

In Figure 19 all axis systems shown are parallel and the dynamically equivalent mass system is the same as shown in Figure 18. Figure 20 shows the equivalent mass system dimensioned relative to the x''''-y''''-z'''' axis system. The accelerations of the x''''-y''''-z'''' axis system are, from Figure 19:

$-\Omega^2 R$ in the z direction

$-\left(\Omega^2 + \omega^2\right)\Delta x$ in the x direction

$-\omega^2 \Delta y$ in the y direction

If b_X, b_Y, and b_Z are the x''', y''', z''' coordinates of a mass, m, then the forces produced by that mass are:

$$F_Z = m\left[\Omega^2\left(R + b_Z\right) + \omega^2\psi\left(\bar{X} - b_X\right) + \omega^2\beta\left(-\bar{Y} - b_Y\right)\right]$$

$$F_X = m\left[\Omega^2\left(-\bar{X} + b_X\right) + \omega^2\phi\left(\bar{Y} + b_Y\right) + \omega^2\psi\left(b_Z\right) + \left(\Omega^2 + \omega^2\right)\Delta X\right]$$

$$F_Y = m\left[\omega^2\phi\left(\bar{X} - b_X\right) + \omega^2\beta\left(b_Z\right) + \omega^2\Delta Y\right]$$

Where:

$$r_X = r_C \cos\theta + r_B \sin\theta$$

$$r_Y = r_C \sin\theta - r_B \cos\theta$$

$$\bar{X} = r_X - \phi r_Y$$

$$\bar{Y} = r_Y + \phi r_X$$

From Figure 20:

	b_X	b_Y	b_Z
m_X	$\pm a_X \cos\gamma$	$\pm a_X \sin\gamma$	$\pm a_X\left(\beta\sin\theta - \psi\cos\theta\right)$
m_Y	$\pm a_Y \sin\gamma$	$\pm a_Y \cos\gamma$	$\mp a_Y\left(\beta\cos\theta + \psi\sin\theta\right)$
m_Z	$\pm \psi a_Z$	$\pm \beta a_Z$	$\pm a_Z$

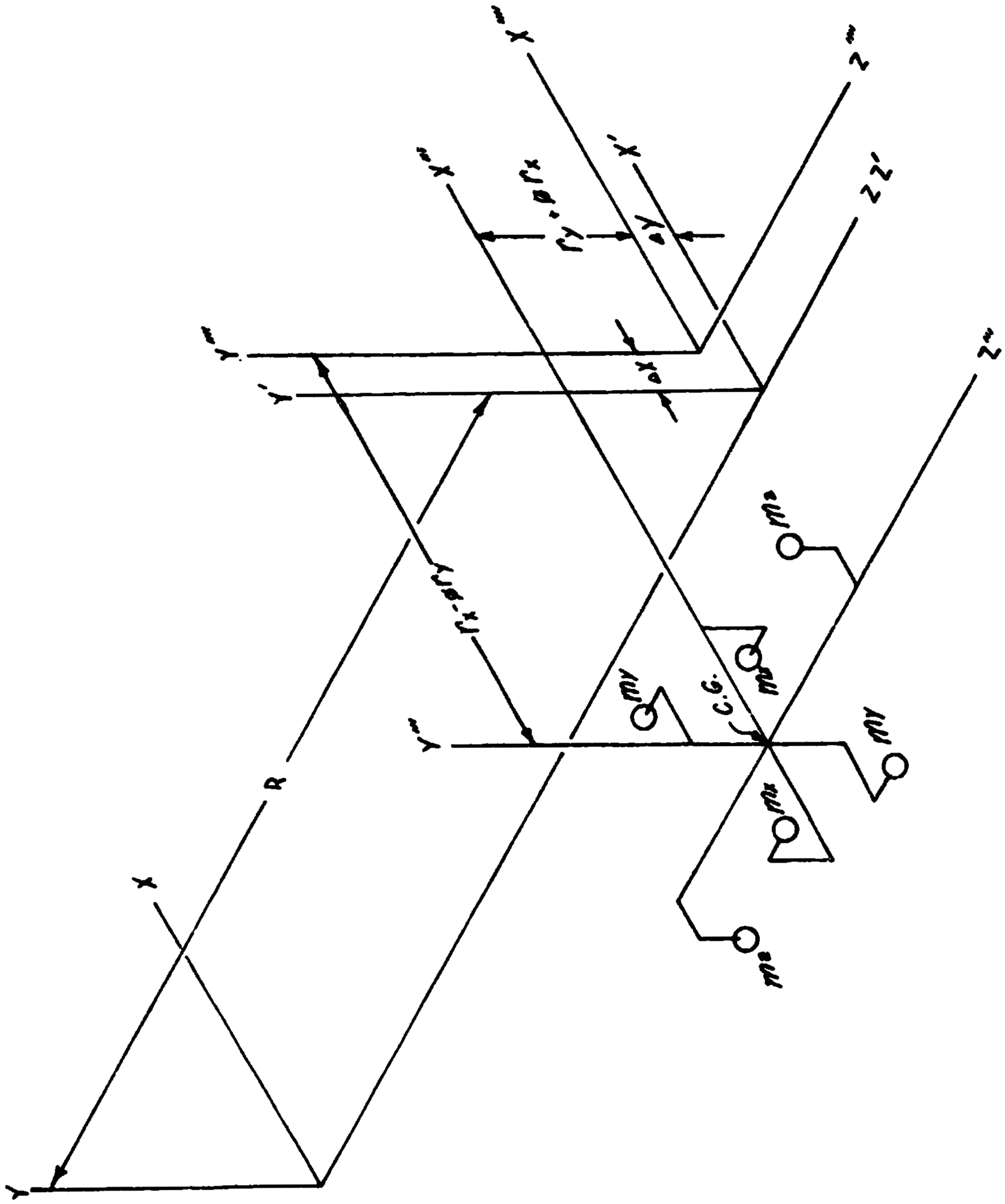


Figure 19.

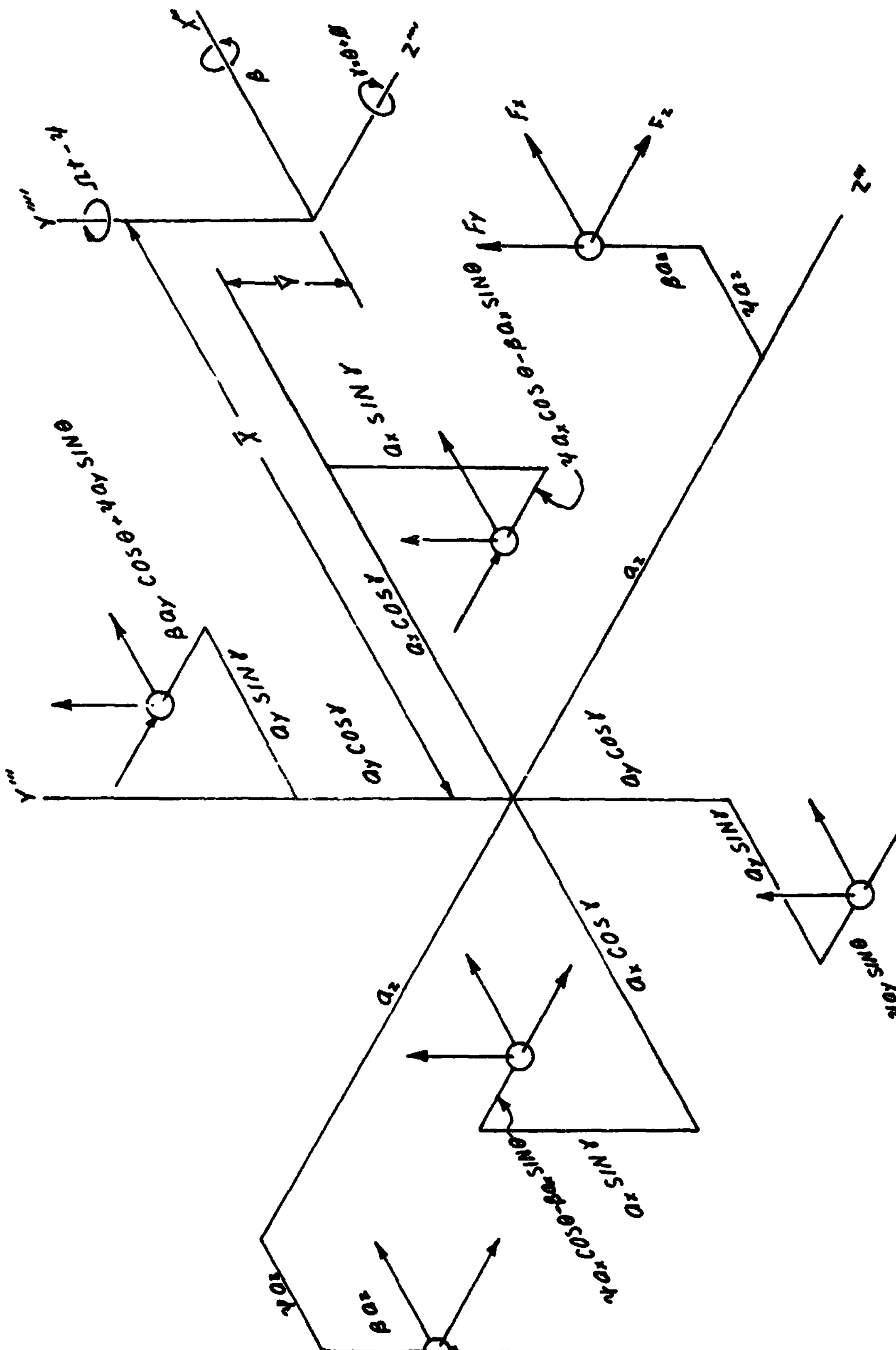


Figure 20.

Since Δx, Δy, ϕ, β, and ψ represent small displacements, products of these terms may be ignored. The forces are:

<u>Produced by</u>

$\underline{F_Z}$

m_X
$$m_X\left[\Omega^2\left(R \pm a_X\beta\ \mathrm{SIN}\,\theta \mp a_X\psi\ \mathrm{COS}\,\theta\right) + \omega^2\psi\left(\overline{X} \mp a_X\ \mathrm{COS}\,\theta\right) + \omega^2\beta\left(-\overline{Y} \pm a_X\ \mathrm{SIN}\,\theta\right)\right]$$

m_Y
$$m_Y\left[\Omega^2\left(R \mp a_Y\beta\ \mathrm{COS}\,\theta \mp a_Y\psi\ \mathrm{SIN}\,\theta\right) + \omega^2\psi\left(\overline{X} \mp a_Y\ \mathrm{SIN}\,\theta\right) + \omega^2\beta\left(-\overline{Y} \mp a_Y\ \mathrm{COS}\,\theta\right)\right]$$

m_Z
$$m_Z\left[\Omega^2\left(R \pm a_Z\right) + \omega^2\psi\left(\overline{X}\right) + \omega^2\beta\left(-\overline{Y}\right)\right]$$

$\underline{F_X}$

m_X
$$m_X\left[\Omega^2\left(-\overline{X} \pm a_X\ \mathrm{COS}\,\gamma\right) + \omega^2\phi\left(\overline{Y} \mp a_X\ \mathrm{SIN}\,\theta\right) + \left(\Omega^2 + \omega^2\right)\Delta X\right]$$

m_Y
$$m_Y\left[\Omega^2\left(-\overline{X} \pm a_Y\ \mathrm{SIN}\,\gamma\right) + \omega^2\phi\left(\overline{Y} \pm a_Y\ \mathrm{COS}\,\theta\right) + \left(\Omega^2 + \omega^2\right)\Delta X\right]$$

m_Z
$$m_Z\left[\Omega^2\left(-\overline{X} \pm \psi a_Z\right) + \omega^2\phi\left(\overline{Y}\right) + \omega^2\psi\left(\pm a_Z\right) + \left(\Omega^2 + \omega^2\right)\Delta X\right]$$

$\underline{F_Y}$

m_X
$$m_X\left[\omega^2\phi\left(\overline{X} \mp a_X\ \mathrm{COS}\,\theta\right) + \omega^2\Delta Y\right]$$

m_Y
$$m_Y\left[\omega^2\phi\left(\overline{X} \mp a_Y\ \mathrm{SIN}\,\theta\right) + \omega^2\Delta Y\right]$$

m_Z
$$m_Z\left[\omega^2\phi\left(\overline{X}\right) + \omega^2\beta\left(\pm a_Z\right) + \omega^2\Delta Y\right]$$

Where: $\gamma = \theta + \phi$

Summing the forces, subtracting the centrifugal force term, $\Omega^2 Rm$, and making the substitution, $m = 2\left(m_X + m_Y + m_Z\right)$:

$$F_Z = \omega^2 m\left(\psi r_X - \beta r_Y\right)$$

$$F_X = -\Omega^2 m r_X + \phi\left(\Omega^2 + \omega^2\right) m r_Y + \left(\Omega^2 + \omega^2\right) m\Delta X$$

$$F_Y = \omega^2 \phi m r_X + \omega^2 m \Delta Y$$

The moments about the x'''-y'''-z''' origin, substituting I_{ZZ}, I_{BB} and I_{CC}, are:

Due to

T'

m_X $\quad I_{CC}\left[\left(\mp \text{SIN}\gamma\right)\left(\pm\Omega^2 \text{COS}\gamma \mp \omega^2 \phi \text{SIN}\theta\right) + \left(\mp\text{COS}\gamma\right)\left(\mp\omega^2 \phi \text{ COS}\theta\right)\right]$

m_Y $\quad I_{BB}\left[\left(\pm \text{COS}\gamma\right)\left(\pm \Omega^2 \text{ SIN}\gamma \pm \omega^2 \phi \text{COS}\theta\right) + \left(\mp\text{SIN}\gamma\right)\left(\mp\omega^2 \phi \text{ SIN}\theta\right)\right]$

m_Z $\quad I_{ZZ}\left[\left(\pm\beta\right)\left(\pm \Omega^2\psi \pm \omega^2\psi\right) + \left(\mp\psi\right)\left(\pm \omega^2\beta\right)\right]$

M'

m_X $\quad I_{CC}\left[\left(\pm\beta\text{SIN}\theta \mp \psi\text{COS}\theta\right)\left(\mp\omega^2\phi\text{COS}\theta\right) + \left(\pm\text{SIN}\gamma\right)\left(\Omega^2 + \omega^2\right)\left(\pm\beta\text{SIN}\theta \mp \psi\text{COS}\theta\right)\right]$

m_Y $\quad I_{BB}\left[\left(\mp\beta\text{COS}\theta \mp \psi\text{SIN}\theta\right)\left(\mp\omega^2\phi\text{SIN}\theta\right) + \left(\mp\text{COS}\gamma\right)\left(\Omega^2 + \omega^2\right)\left(\mp\beta\text{COS}\theta \mp \psi\text{SIN}\theta\right)\right]$

m_Z $\quad I_{ZZ}\left[\left(\pm 1\right)\left(\pm\omega^2\beta\right) + \left(\mp\beta\right)\left(\pm\Omega^2\right)\right]$

Q'

m_X $\quad I_{CC}\left[\left(\pm\beta\text{SIN}\theta \mp \psi\text{COS}\theta\right)\left(\pm\Omega^2\text{COS}\gamma \mp \omega^2\phi\text{SIN}\theta\right)\right.$

$\qquad\qquad \left.\mp \text{COS}\gamma\left(\Omega^2 + \omega^2\right)\left(\pm\beta\text{SIN}\theta \mp \psi\text{COS}\theta\right)\right]$

m_Y $\quad I_{BB}\left[\left(\mp\beta\text{COS}\theta \mp \psi\text{SIN}\theta\right)\left(\pm\Omega^2\text{SIN}\gamma \pm \omega^2\phi\text{COS}\theta\right)\right.$

$\qquad\qquad \left.\pm \text{SIN}\gamma\left(\Omega^2 + \omega^2\right)\left(\mp\beta\text{COS}\theta \mp \psi\text{SIN}\theta\right)\right]$

m_Z $\quad I_{ZZ}\left[\left(\pm 1\right)\left(\pm\Omega^2\psi \pm \omega^2\psi\right) + \left(\mp\psi\right)\left(\pm\Omega^2\right)\right]$

Summing and subtracting static moments:

$$T' = I_{CC}\left(-\Omega^2\phi\cos 2\theta + \omega^2\phi\sin^2\theta + \omega^2\phi\cos^2\theta\right)$$

$$+ I_{BB}\left(\Omega^2\phi\cos 2\theta + \omega^2\phi\cos^2\theta + \omega^2\phi\sin^2\theta\right)$$

$$M' = I_{CC}\left(\Omega^2\beta\sin^2\theta - \Omega^2\psi\sin\theta\cos\theta - \omega^2\psi\sin\theta\cos\theta + \omega^2\beta\sin^2\theta\right)$$

$$+ I_{BB}\left(\Omega^2\beta\cos^2\theta + \Omega^2\psi\sin\theta\cos\theta + \omega^2\psi\sin\theta\cos\theta + \omega^2\beta\cos^2\theta\right)$$

$$+ I_{ZZ}\left(\omega^2\beta - \Omega^2\beta\right)$$

$$Q' = I_{CC}\left(\omega^2\psi\cos^2\theta - \omega^2\beta\sin\theta\cos\theta\right)$$

$$+ I_{BB}\left(\omega^2\psi\sin^2\theta + \omega^2\beta\sin\theta\cos\theta\right)$$

$$+ I_{ZZ}\left(\omega^2\psi\right)$$

$$T' = \phi\left[\Omega^2\left(I_{BB} - I_{CC}\right)\cos 2\theta + \omega^2\left(I_{BB} + I_{CC}\right)\right]$$

$$M' = \beta\Big[\Omega^2\left(-I_{ZZ} + I_{BB}\cos^2\theta + I_{CC}\sin^2\theta\right)$$

$$+ \omega^2\left(I_{ZZ} + I_{BB}\cos^2\theta + I_{CC}\sin^2\theta\right)\Big]$$

$$+ \psi\left[\left(\Omega^2 + \omega^2\right)\left(I_{BB} - I_{CC}\right)\sin\theta\cos\theta\right]$$

$$Q' = \omega^2\beta\left(I_{BB} - I_{CC}\right)\sin\theta\cos\theta + \omega^2\psi\left(I_{ZZ} + I_{BB}\sin^2\theta + I_{CC}\cos^2\theta\right)$$

Taking the moments about the x'''-y'''-z''' axis due to F_X, F_Y, and F_Z and ignoring the centrifugal force term, $\Omega^2 Rm$:

$$T' = \bar{y}F_X + \bar{x}F_Y$$

$$M' = -\bar{y}F_Z$$

$$Q' = \bar{x}F_Z$$

$$T' = m\left(r_Y + \phi r_X\right)\left[-\Omega^2 r_Y + (\Omega^2 + \omega^2)\left(\Delta_X + \phi r_Y\right)\right] + m\left(r_X - \phi r_Y\right)(\omega^2)\left(\Delta_Y + \phi r_X\right)$$

$$M' = -m\left(r_Y + \phi r_X\right)(\omega^2)\left(\psi r_X - \beta r_Y\right)$$

$$Q' = m\left(r_X - \phi r_Y\right)(\omega^2)\left(\psi r_Y - \beta r_X\right)$$

Summing moments and subtracting static terms:

$$F_X = \phi(\Omega^2 + \omega^2)mr_Y + (\Omega^2 + \omega^2)m\Delta x$$

$$F_Y = \omega^2 \phi\, mr_X + \omega^2 m\Delta y$$

$$T' = \phi\left\{\Omega^2\left[(I_{BB} - I_{CC})\cos 2\theta + m\left(r_Y^2 - r_X^2\right)\right] + \omega^2\left[I_{BB} + I_{CC} + m\left(r_X^2 + r_Y^2\right)\right]\right\}$$

$$M' = \beta\left[\Omega^2\left(-I_{ZZ} + I_{BB}\cos^2\theta + I_{CC}\sin^2\theta\right) + \omega^2\left(I_{ZZ} + I_{BB}\cos^2\theta + I_{CC}\sin^2\theta + mr_Y^2\right)\right] + \psi\left[(\Omega^2 + \omega^2)\left(I_{BB} - I_{CC}\right)\sin\theta\cos\theta - \omega^2 mr_X r_Y\right]$$

$$Q' = \omega^2\beta\left[(I_{BB} - I_{CC})\sin\theta\cos\theta - mr_X r_Y\right] + \omega^2\psi\left(I_{ZZ} + I_{BB}\sin^2\theta + I_{CC}\cos^2\theta + mr_X^2\right)$$

Let: $I_C = I_{ZZ} + I_{BB}$

$$I_B = I_{ZZ} + I_{CC}$$

$$I_R = I_{BB} + I_{CC} + m\left(r_X{}^2 + r_Y{}^2\right)$$

$$M_{\beta\beta\Omega} = -I_{ZZ} + I_{BB}\mathrm{COS}^2\theta + I_{CC}\mathrm{SIN}^2\theta$$

$$M_{\beta\beta\omega} = I_C\mathrm{COS}^2\theta + I_B\mathrm{SIN}^2\theta + mr_Y{}^2$$

$$M_{\beta\psi\Omega} = \left(I_C - I_B\right)\mathrm{SIN}\,\theta\,\mathrm{COS}\,\theta$$

$$M_{\beta\psi\omega} = \left(I_C - I_B\right)\mathrm{SIN}\,\theta\,\mathrm{COS}\,\theta - mr_Xr_Y$$

$$M_{\psi\psi\omega} = I_C\mathrm{SIN}^2\theta + I_B\mathrm{COS}^2\theta + mr_X{}^2$$

$$T_{\phi\phi\Omega} = \left(I_{BB} - I_{CC}\right)\mathrm{COS}2\theta + m\left(r_Y{}^2 - r_X{}^2\right)$$

Changes in forces and moments due to mass system ignoring centrifugal force term, $\Omega^2 mR$, become:

$$L' = \omega^2 mr_X\phi + \omega^2 m\Delta y$$

$$D' = \left(\Omega^2 + \omega^2\right)mr_{[illegible]}\phi + \left(\Omega^2 + \omega^2\right)m\Delta x$$

$$M' = \left(\Omega^2 M_{\beta\beta\Omega} + \omega^2 M_{\beta\beta\omega}\right)\beta + \left(\Omega^2 M_{\beta\psi\Omega} + \omega^2 M_{\beta\psi\omega}\right)\psi$$

$$Q' = \omega^2 M_{\beta\psi\omega}\beta + \omega^2 M_{\psi\psi\omega}\psi$$

$$T' = \left(\Omega^2 T_{\phi\phi\Omega} + \omega^2 I_R\right)\phi$$

C. Action line of centrifugal force, F

Figures 21 and 22 show schematically the forces and moments acting on a section. F is the centrifugal force and F_{TX} and F_{TY} are moments due to the centrifugal forces.

$$F_{sta\ i} = \sum_{tip}^{sta\ i} \Omega^2 mz$$

$$F_{TX_i} = \sum \Omega^2 mzr_X$$

$$F_{TY_i} = \sum \Omega^2 mzr_Y$$

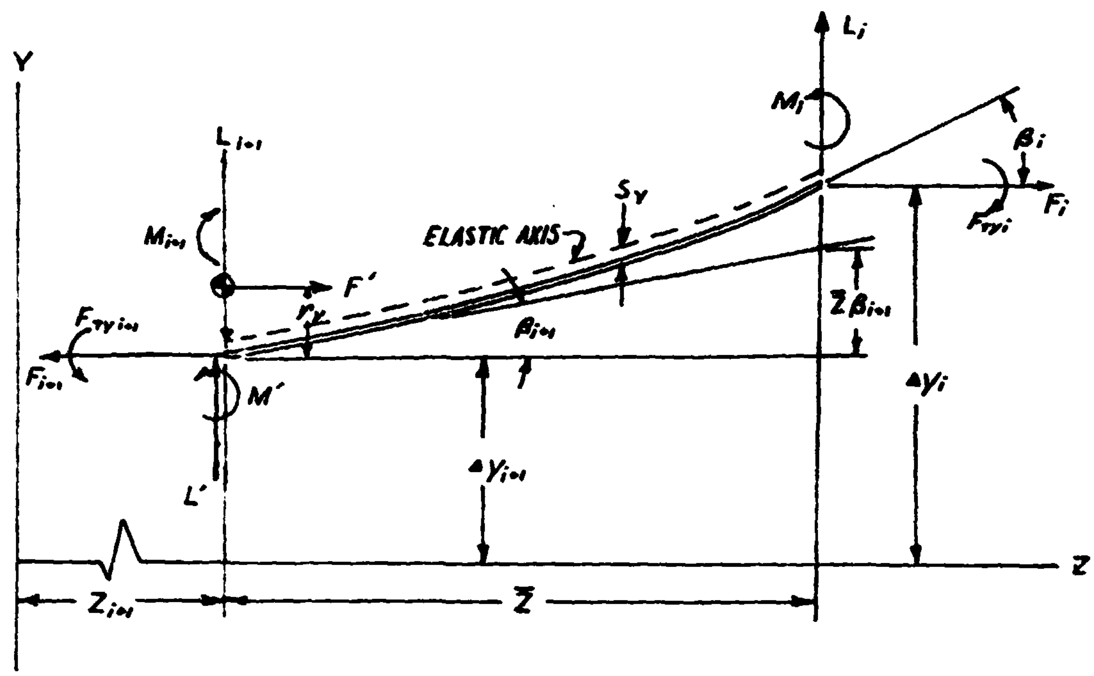


Figure 21.

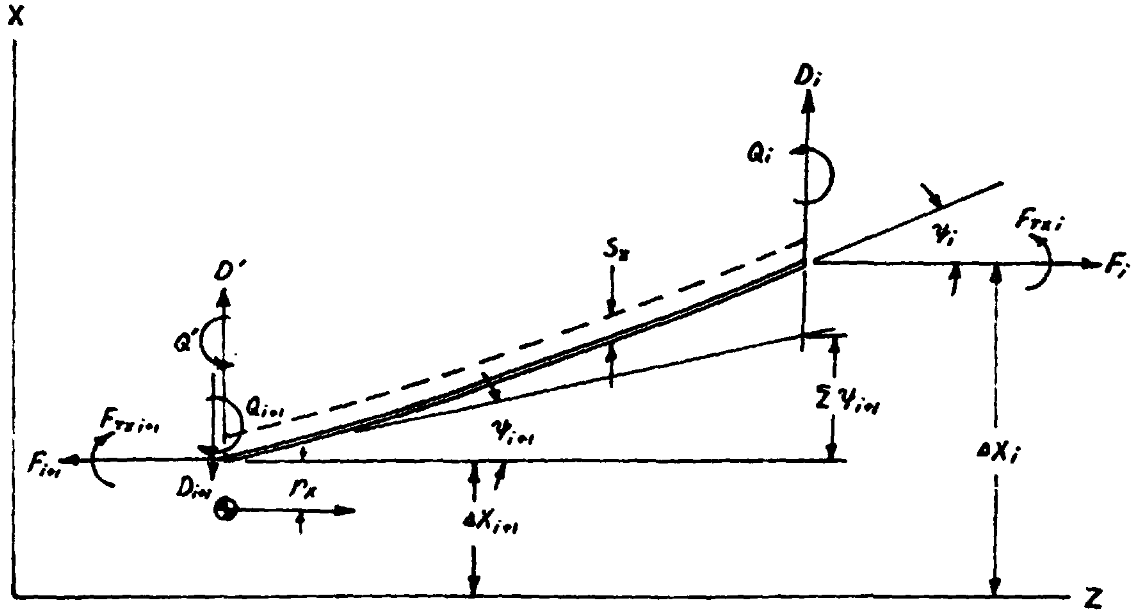


Figure 22.

D. Recurrence Formulas

Referring to Figures 10 through 17, 21, and 22:

$$\beta_{i+1} = \beta_i - M_i\nu_{MY} - Q_i\nu_{QY} - (L_i - F_i\beta_i)\nu_{LY} - (D_i - F_i\psi_i)\nu_{DY}$$

$$\Delta y_{i+1} = \Delta y_i - \bar{z}\beta_{i+1} - M_i d_{MY} - Q_i d_{QY} - (L_i - F_i\beta_i)d_{LY} - (D_i - F_i\psi_i)d_{DY} - T_i d_{TY}$$

$$\psi_{i+1} = \psi_i - M_i\nu_{MX} - Q_i\nu_{QX} - (L_i - F_i\beta_i)\nu_{LX} - (D_i - F_i\psi_i)\nu_{DX}$$

$$\Delta X_{i+1} = \Delta x_i - M_i d_{MX} - Q_i d_{QX} - (L_i - F_i\beta_i)d_{LX} - (D_i - F_i\psi_i)d_{DX} - \bar{z}\psi_{i+1} - T_i d_{TX}$$

$$L_{i+1} = L_i + L'$$

$$D_{i+1} = D_i + D'$$

$$M_{i+1} = M_i - F_i(\Delta Y_i - \Delta y_{i+1}) - F_{TXi}(\phi_i - \phi_{i+1}) + L_i\bar{z} + M'$$

$$Q_{i+1} = Q_i - F_i(\Delta x_i - \Delta x_{i+1}) - F_{TYi}(\phi_i - \phi_{i+1}) + D_i\bar{z} + Q'$$

$$T_{i+1} = T_i - F_{TX}(\beta_i - \beta_{i+1}) - F_{TY}(\psi_i - \psi_{i+1}) + T'$$

$$\phi_{i+1} = \phi_i + W_{FL}\beta_i + W_{FD}\psi_i - W_L L_i - W_D D_i - W_T T_i$$

Introduce the following quantities that do not depend on F:

$$d'_{LY} = d_{LY} - \bar{z}\nu_{LY}$$

$$d'_{DY} = d_{DY} - \bar{z}\nu_{DY}$$

$$d'_{MY} = d_{MY} - \bar{z}\nu_{MY}$$

$$d'_{QY} = d_{QY} - \bar{z}\nu_{QY}$$

$$d'_{LX} = d_{LX} - \bar{z}\nu_{LX}$$

$$d'_{DX} = d_{DX} - \bar{z}\nu_{DX}$$

$$d'_{MX} = d_{MX} - \bar{z}\nu_{MX}$$

$$d'_{QX} = d_{QX} - \bar{z}\nu_{QX}$$

Introduce the following quantities that do depend on F.

$d_{FLY} = F_i d'_{LY} - \bar{z}$

$d_{FDY} = F_i d'_{DY}$

$d_{FLX} = F_i d'_{LX}$

$d_{FDX} = F_i d'_{DX} - \bar{z}$

$\nu_{FLY} = F_i \nu_{LY}$

$\nu_{FDY} = F_i \nu_{DY}$

$\nu_{FDX} = F_i \nu_{DX}$

$\nu_{FLX} = F_i \nu_{LX}$

$W_{FL} = F_i W_L$

$W_{FD} = F_i W_D$

Introduce:

$\delta\beta = \nu_{FLY}\beta_i + \nu_{FDY}\psi_i - \nu_M M_i - \nu_{QY} Q_i - \nu_{LY} L_i - \nu_{DY} D_i$

$\delta y = d_{FLY}\beta_i + d_{FDY}\psi_i - d'_{MY} M_i - d'_{QY} Q_i - d'_{LY} L_i - d'_{DY} D_i - d_{TY} T_i$

$\delta\psi = \nu_{FDX}\psi_i + \nu_{FLX}\beta_i - \nu_{MX} M_i - \nu_{QX} Q_i - \nu_{LX} L_i - \nu_{DX} D_i$

$\delta x = d_{FLX}\beta_i + d_{FDX}\psi_i - d'_{MX} M_i - d'_{QX} Q_i - d'_{LX} L_i - d'_{DX} D_i - d_{TX} T_i$

$\delta\phi = W_{FL}\beta_i + W_{FD}\psi_i - W_L L_i - W_D D_i - W_T T_i$

The recurrence formulas then become:

$$\beta_{i+1} = \beta_i + \delta\beta$$

$$\Delta y_{i+1} = \Delta y_i + \delta y$$

$$\psi_{i+1} = \psi_i + \delta\psi$$

$$\Delta x_{i+1} = \Delta x_i + \delta x$$

$$\phi_{i+1} = \phi_i + \delta\phi$$

$$L_{i+1} = L_i + M_{i+1} r_{xi+1} \omega^2 \phi_{i+1} + m_{i+1} \omega^2 \Delta y_{i+1}$$

$$D_{i+1} = D_i + (\Omega^2 + \omega^2) m_{i+1} r_{yi+1} \phi_{i+1} + (\Omega^2 + \omega^2) m_{i+1} \Delta x_{i+1}$$

$$M_{i+1} = F_i \delta y + F_{TX} \delta\phi + M_i + \bar{z} L_i + \left(M_{\beta\beta\omega}\omega^2 + M_{\beta\beta\Omega}\Omega^2\right)\beta_{i+1} + \left(M_{\beta\psi\omega}\omega^2 + M_{\beta\psi\Omega}\Omega^2\right)\psi_{i+1}$$

$$Q_{i+1} = F_i \delta x + F_{TY} \delta\phi + Q_i + \bar{z} D_i + \omega^2 M_{\beta\psi\omega} \beta_{i+1} + \omega^2 M_{\psi\psi\omega} \psi_{i+1}$$

$$T_{i+1} = F_{TX} \delta\beta + F_{TY} \delta\psi + T_i + \left(\omega^2 I_R + \Omega^2 T_{\phi\phi\Omega}\right)\phi_{i+1} + (\Omega^2 + \omega^2)\, m_{i+1} r_{Yi+1} \Delta x_{i+1} + \omega^2 m_{i+1} r_{Xi+1} \Delta y_{i+1}$$

Since the forces and moments are calculated inb'd of the masses they will not be zero at the tip. The tip values are:

$$L_{TIP} = L'_{TIP}$$

$$D_{TIP} = D'_{TIP}$$

$$M_{TIP} = M'_{TIP}$$

$$Q_{TIP} = Q'_{TIP}$$

$$T_{TIP} = T'_{TIP}$$

APPENDIX B
SAMPLE PROBLEM

PLEASE RETURN TO J.P. VAN GAASBEEK, VTOL TECHNOLOGY, EXT. 3956

PLEASE RETURN TO J.R. VAN GAASBEEK, VTOL TECHNOLOGY, EXT. 3956

PLEASE RETURN TO J.R. VAN GAASBEEK, VTOL TECHNOLOGY, EXT. 3956

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PLEASE RETURN TO J.P. VAN GAASBEEK, VTOL TECHNOLOGY, EXT. 3956

PAGE 1 BHC PROGRAM DF175A -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-02-74

	SEGMENT LENGTH (IN)	EI (LB-IN**2) BEAM (E-6)	CHORD (E-6)	WT/IN (LB/IN)	TWIST AT INBD END (DEG)	CF AT INBD END (LB/RPM)
1	13.20	14.9	.310E+04	4.68	.0	1.1024
2	13.20	127.	.191E+04	7.25	-.500	1.0909
3	13.20	356.	.175E+04	5.69	-1.00	1.0371
4	13.20	256.	.511E+04	4.60	-1.50	.96676
5	13.20	89.5	.424E+04	.952	-2.00	.88714
6	13.20	63.1	.405E+04	.761	-2.50	.86506
7	13.20	50.0	.395E+04	.673	-3.00	.84526
8	13.20	46.3	.389E+04	.651	-3.50	.82363
9	13.20	42.0	.364E+04	.611	-4.00	.79948
10	13.20	37.5	.342E+04	.577	-4.50	.77380
11	13.20	33.1	.320E+04	.541	-5.00	.74670
12	13.20	33.0	.299E+04	.690	-5.50	.71861
13	13.20	35.0	.283E+04	1.18	-6.00	.67927
14	13.20	35.0	.262E+04	1.18	-6.50	.60643
15	13.20	32.6	.239E+04	.780	-7.00	.52765
16	13.20	32.3	.220E+04	.501	-7.50	.47173
17	13.20	32.5	.206E+04	.501	-8.00	.43333
18	13.20	33.2	.208E+04	.504	-8.50	.39245
19	13.20	46.4	.226E+04	1.67	-9.00	.34883
20	13.20	46.4	.229E+04	2.04	-9.50	.19642

RADIUS= 264.00 IN

2 HUB SEGMENTS

TWIST AT TIP= -10.000 DEG

	INITIAL	FINAL	DELTA
ROTOR RPM	310.00	338.00	14.00
ROOT COLL (DEG)	10.00	20.00	5.00
FREQ SWEEP (CPM)	232.50	2028.00	62.00

TIPWEIGHT	.0	LBM	MAST TOR STIF	.0	IN-LBF/DEG
VSOFT	.0	/LBF	VMASS	.0	LBM/BLADE
HSOFT	.0	/LBF	HMASS	.0	LBM/BLADE
FLP SPRING/BLD	.0	FT-LBF/DEG	INPL SPRG/BLD	.0	FT-LBF/DEG
FLP HNG OFFSET	.0	INCH	INPL HNG OFFSET	.0	INCH
NUMBER OF BLDS	2.00		PITCH HORN OFFSET	41.0000	INCH
HUB TYPE	GIMBALED		CHORD	27.000	INCHES
BLADE MASS	476.	LBM	FLAP INERTIA	.138E+04	SLUG-FT**2/BLADE
BLADE LOCK NUMBER	5.20				

PAGE 2 BHC PROGRAM DF175R -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *

	IBB (IN-LB-SEC**2/IN)	BEAM RAD. OF GYRATION (IN)	ICC (IN-LB-SEC**2/IN)	CHORD RAD. OF GYRATION (IN)
1	0.10000E-03	.9086E-01	0.69100E-01	2.389
2	0.89800E-01	2.188	0.13320E+00	2.664
3	0.89800E-01	2.469	0.49300E-01	1.830
4	0.64000E-02	.7332	0.24180E+00	4.507
5	0.24000E-02	.9870	0.11830E+00	6.929
6	0.17000E-02	.9291	0.11140E+00	7.521
7	0.13000E-02	.8639	0.10840E+00	7.889
8	0.13000E-02	.8784	0.10680E+00	7.962
9	0.12000E-02	.8711	0.10200E+00	8.032
10	0.10000E-02	.8183	0.97200E-01	8.068
11	0.90000E-03	.8018	0.92000E-01	8.106
12	0.10000E-02	.7483	0.89500E-01	7.080
13	0.20000E-02	.8093	0.94000E-01	5.548
14	0.20000E-02	.8093	0.90500E-01	5.444
15	0.10000E-02	.7038	0.77400E-01	6.192
16	0.90000E-03	.8331	0.72000E-01	7.452
17	0.90000E-03	.8331	0.66000E-01	7.135
18	0.90000E-03	.8307	0.67500E-01	7.194
19	0.14000E-02	.5698	0.77600E-01	4.242
20	0.21000E-02	.6312	0.84600E-01	4.006

PAGE 3 BHC PROGRAM DF175A -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *
CONTROL SYSTEM STIFFNESS= 0.36900E+06 IN-LB

	SHEAR CENTER OFFSET(IN), BEAM	CHORD	C.G. OFFSET (IN) BEAM	CHORD	GJ(LB-IN**2)
1	0.0	0.0	0.0	0.0	0.36000E+08
2	0.0	0.0	0.0	-0.120	0.36000E+08
3	0.0	0.0	0.0	-3.610	0.36000E+08
4	0.0	1.190	0.0	-1.430	0.69400E+08
5	0.0	0.560	0.0	-0.900	0.74000E+08
6	0.0	0.640	0.0	-1.320	0.63000E+08
7	0.0	1.200	0.0	-1.700	0.55200E+08
8	0.0	1.160	0.0	-1.610	0.50000E+08
9	0.0	0.970	0.0	-1.450	0.43200E+08
10	0.0	0.750	0.0	-1.260	0.38100E+08
11	0.0	0.530	0.0	-1.100	0.34500E+08
12	0.0	0.290	0.0	-0.530	0.33800E+08
13	0.0	-0.220	0.0	1.350	0.33800E+08
14	0.0	-0.450	0.0	1.510	0.33800E+08
15	0.0	-0.690	0.0	-0.070	0.33800E+08
16	0.0	-0.610	0.0	-0.250	0.33800E+08
17	0.0	-0.850	0.0	-0.080	0.33800E+08
18	0.0	-1.100	0.0	0.150	0.33800E+08
19	0.0	-2.510	0.0	2.420	0.33800E+08
20	0.0	-2.520	0.0	2.450	0.33800E+08
TW			0.0	0.0	

PAGE 4 BHC PROGRAM DF175R -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *
COLLECTIVE MODE OF BLADE AT 339.13 CPM
NATURAL FREQUENCY IS: 1.0436 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN VERT PLANE - 1 MODE
MAX DEFLECTION PLANE AT -89.7 DEG

	BLADE STA IN	DEFLECTIONS IN(1)		MOMENTS IN-LB(1)		SHEAR FORCES LB(1)		TWIST DEG(1)	TORQUE IN-LB(1)
		VERT	HORIZ	BEAM	CHORD	BEAM	CHORD		
					HUB				
1	0.0	0.000	0.000	6307.	0.	436.	-3.	0.039	0.
2	13.20	0.022	-0.001	3096.	-64.	434.	-3.	0.039	0.
3	26.40	0.065	-0.002	2335.	-123.	428.	-3.	0.039	0.
					** BLADE **				
3	26.40	0.065	-0.002	2736.	-685.	418.	-106.	0.039	0.
4	39.60	0.111	-0.003	1657.	-586.	399.	-98.	0.039	0.
5	52.80	0.157	-0.003	1132.	-501.	376.	-87.	0.039	292.
6	66.00	0.205	-0.004	709.	-429.	359.	-79.	0.043	327.
7	79.20	0.255	-0.004	424.	-370.	352.	-74.	0.047	344.
8	92.40	0.305	-0.004	251.	-320.	345.	-69.	0.052	363.
9	105.60	0.357	-0.003	149.	-275.	338.	-65.	0.058	382.
10	118.80	0.410	-0.003	90.	-234.	329.	-60.	0.065	400.
11	132.00	0.462	-0.002	59.	-197.	319.	-55.	0.074	417.
12	145.20	0.515	-0.002	45.	-164.	309.	-50.	0.083	432.
13	158.40	0.569	-0.001	43.	-134.	296.	-45.	0.093	444.
14	171.60	0.622	-0.000	40.	-107.	273.	-39.	0.102	431.
15	184.80	0.676	0.000	33.	-83.	242.	-32.	0.111	387.
16	198.00	0.730	0.001	25.	-63.	215.	-27.	0.119	363.
17	211.20	0.784	0.002	21.	-47.	195.	-22.	0.128	365.
18	224.40	0.838	0.002	17.	-33.	178.	-19.	0.136	369.
19	237.60	0.892	0.003	14.	-20.	161.	-15.	0.144	368.
20	250.80	0.946	0.004	5.	-10.	119.	-10.	0.151	290.
21	264.00	1.000	0.005	0.	-3.	44.	-3.	0.153	107.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.22285 IN-LBF-SEC**2

ORIGINAL PAGE IS OF POOR QUALITY

PAGE 5 BHC PROGRAM DF1758 -COMPILED 02/25/75 02/26/75
540015

NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74

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COLLECTIVE MODE OF BLADE AT 858.29 CPM

NATURAL FREQUENCY IS: 2.6490 PER REV

15.00 DEGREE ROOT COLLECTIVE

324.00 ROTOR RPM

MAXIMUM AMPLITUDE IN VERT PLANE - 2 NODES

MAX DEFLECTION PLANE AT -76.9 DEG

	BLADE STA IN	DEFLECTIONS IN(1) VERT	DEFLECTIONS IN(1) HORIZ	MOMENTS IN-LB(1) BEAM	MOMENTS IN-LB(1) CHORD	SHEAR FORCES LB(1) BEAM	SHEAR FORCES LB(1) CHORD	TWIST DEG(1)	TORQUE IN-LB(1)
					HUB				
1	0.0	0.000	0.000	-24870.	0.	-2139.	-507.	0.662	0.
2	13.20	-0.082	-0.027	-6027.	3471.	-2139.	-502.	0.662	0.
3	26.40	-0.224	-0.055	4771.	6391.	-2004.	-450.	0.662	0.
					** BLADE **				
	26.40	-0.224	-0.055	6176.	5047.	-2053.	49.	0.662	0.
	39.60	-0.363	-0.081	12829.	5184.	-1610.	46.	0.662	0.
.	52.80	-0.495	-0.105	13619.	5264.	-1036.	45.	0.662	2605.
6	66.00	-0.611	-0.125	11195.	5258.	-634.	44.	0.683	2020.
7	79.20	-0.703	-0.140	9217.	5212.	-483.	42.	0.706	1903.
8	92.40	-0.768	-0.149	7910.	5120.	-337.	41.	0.730	1750.
9	105.60	-0.807	-0.152	7106.	4987.	-189.	42.	0.754	1568.
10	118.80	-0.820	-0.150	6622.	4812.	-47.	45.	0.778	1413.
11	132.00	-0.807	-0.143	6471.	4596.	98.	49.	0.803	1315.
12	145.20	-0.765	-0.130	6843.	4345.	227.	54.	0.830	1297.
13	158.40	-0.690	-0.112	7724.	058.	361.	61.	0.859	1361.
14	171.60	-0.580	-0.088	8224.	3700.	539.	70.	0.897	1641.
15	184.80	-0.434	-0.058	7595.	3238.	723.	81.	0.942	2033.
16	198.00	-0.252	-0.024	6278.	2687.	837.	90.	0.992	2237.
17	211.20	-0.039	0.016	4979.	2084.	881.	96.	1.043	2304.
18	224.40	0.200	0.058	3819.	1455.	886.	101.	1.094	2338.
19	237.60	0.457	0.103	2721.	822.	856.	102.	1.145	2329.
20	250.80	0.726	0.149	1232.	268.	704.	87.	1.183	1943.
21	264.00	1.000	0.196	74.	4.	300.	38.	1.197	814.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.27788 IN-LBF-SEC**2

PAGE 6
540015

BHC PROGRAM DF175R -COMPILED 02/25/75 02/26/75
NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *
COLLECTIVE MODE OF BLADE AT 1047.99 CPM
NATURAL FREQUENCY IS: 3.2345 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN VERT PLANE - 2 NODES
MAX DEFLECTION PLANE AT -81.1 DEG

	BLADE STA	DEFLECTIONS		MOMENTS		SHEAR FORCES		TWIST	TORQUE
	IN	IN(1)		IN-LB(1)		LB(1)		DEG(1)	IN-LB(1)
		VERT	HORIZ	BEAM	CHORD	BEAM	CHORD		
					HUB				
1	0.0	-0.000	0.000	-11856.	0.	-980.	-219.	-4.446	0.
2	13.20	-0.042	-0.015	-4271.	1187.	-980.	-219.	-4.446	0.
3	26.40	-0.119	-0.030	-1556.	1913.	-887.	-178.	-4.446	0.
					** BLADE **				
3	26.40	-0.119	-0.030	-1047.	2233.	-904.	42.	-4.446	0.
4	39.60	-0.198	-0.045	1426.	2268.	-854.	37.	-4.446	0.
5	52.80	-0.282	-0.061	3840.	2329.	-831.	25.	-4.446	-25110.
6	66.00	-0.358	-0.075	4564.	2413.	-619.	19.	-4.685	-23268.
7	79.20	-0.426	-0.087	4827.	2522.	-521.	14.	-4.949	-21908.
8	92.40	-0.485	-0.097	4829.	2639.	-421.	11.	-5.232	-20557.
9	105.60	-0.529	-0.104	4936.	2753.	-337.	9.	-5.524	-19158.
10	118.80	-0.558	-0.107	5135.	2857.	-235.	9.	-5.837	-17710.
11	132.00	-0.566	-0.107	5556.	2947.	-129.	11.	-6.161	-16706.
12	145.20	-0.551	-0.102	6493.	3003.	-26.	14.	-6.485	-14626.
13	158.40	-0.505	-0.092	8115.	3030.	94.	20.	-6.776	-12539.
14	171.60	-0.421	-0.076	9170.	2960.	322.	31.	-7.017	-10847.
15	184.80	-0.296	-0.053	8204.	2727.	618.	47.	-7.207	-8480.
16	198.00	-0.134	-0.025	6238.	2344.	787.	61.	-7.383	-6811.
17	211.20	0.059	0.007	4560.	1868.	814.	71.	-7.465	-4927.
18	224.40	0.275	0.042	3364.	1338.	796.	78.	-7.543	-3477.
19	237.60	0.508	0.079	2660.	787.	739.	81.	-7.591	-2086.
20	250.80	0.752	0.118	1442.	275.	621.	72.	-7.613	-828.
21	264.00	1.000	0.157	106.	7.	287.	34.	-7.620	-49.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.49388 IN-LBF-SEC**2

ORIGINAL PAGE IS
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PAGE 7 BHC PROGRAM DF175R -COMPILED 02/25/75 02/26/75
540015

NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74

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COLLECTIVE MODE OF BLADE AT 1491.54 CPM

NATURAL FREQUENCY IS: 4.6035 PER REV

15.00 DEGREE ROOT COLLECTIVE

324.00 ROTOR RPM

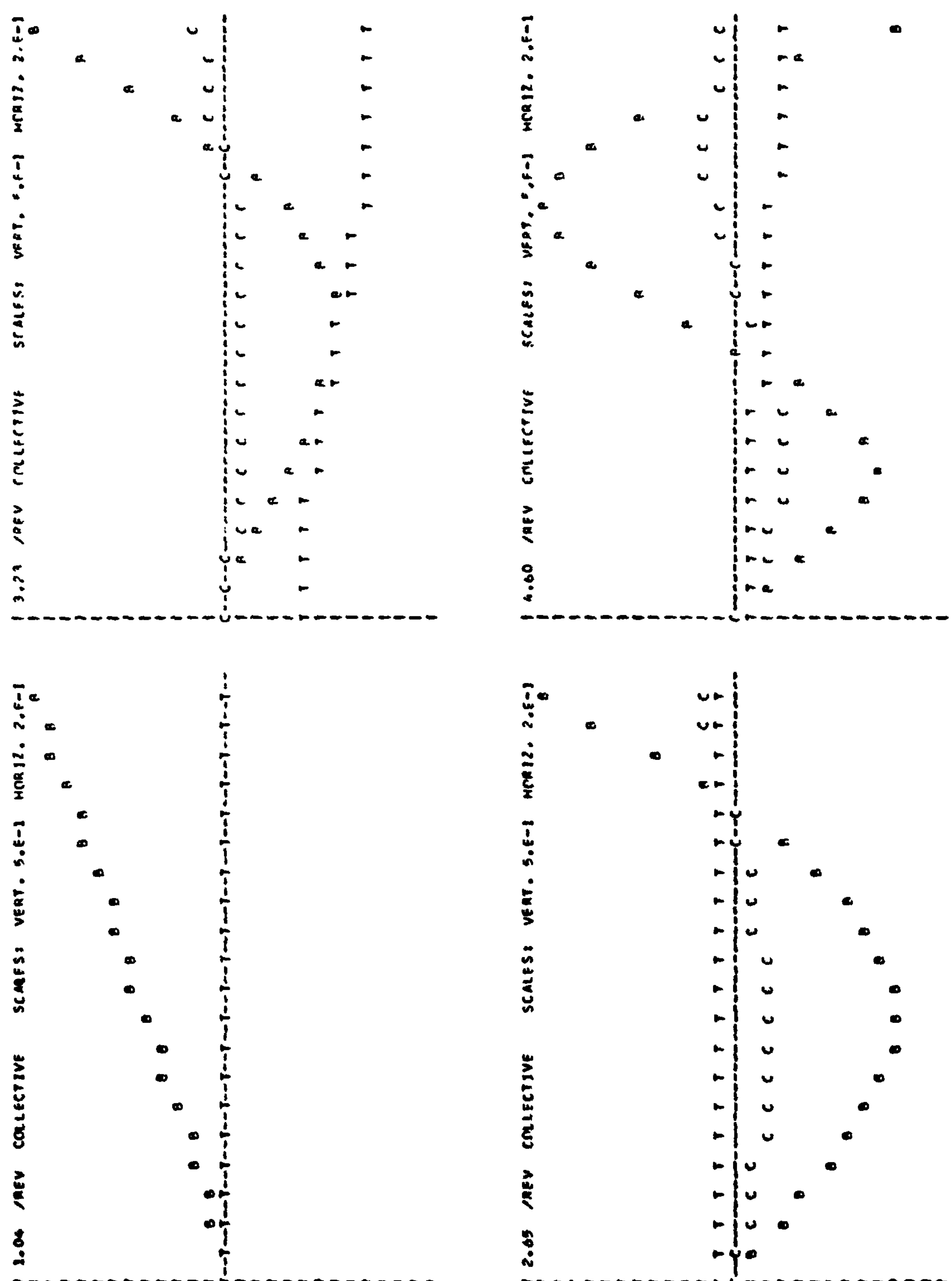
MAXIMUM AMPLITUDE IN VERT PLANE - 3 OR MORE NODES

MAX DEFLECTION PLANE AT -83.2 DEG

	BLADE STA IN	DEFLECTIONS IN(1)		MOMENTS IN-LB(1)		SHEAR FORCES LB(1)		TWIST DEG(1)	TORQUE IN-LB(1)
		VERT	HORIZ	BEAM	CHORD	BEAM	CHORD		
					HUB				
1	0.0	0.0	0.0	-48492.	-0.	-5306.	-2372.	-0.893	0.
2	13.20	-0.152	-0.065	3829.	23991.	-5206.	-2372.	-0.893	0.
3	26.40	-0.359	-0.128	41952.	44203.	-4552.	-2034.	-0.893	0.
					** BLADE **				
3	26.40	-0.359	-0.128	51399.	32741.	-4904.	-872.	-0.893	0.
4	39.60	-0.532	-0.184	72329.	40613.	-2956.	-667.	-0.893	0.
5	52.80	-0.669	-0.229	67849.	45410.	-695.	-403.	-0.893	-9445.
6	66.00	-0.727	-0.254	50076.	47682.	894.	-203.	-0.989	-9970.
7	79.20	-0.678	-0.253	34968.	48876.	1430.	-118.	-1.094	-9191.
8	92.40	-0.531	-0.229	23054.	49108.	1843.	-31.	-1.202	-8506.
9	105.60	-0.307	-0.188	13508.	48410.	2138.	59.	-1.317	-7835.
10	118.80	-0.036	-0.134	5330.	46814.	2297.	150.	-1.478	-7070.
11	132.00	0.257	-0.075	-2042.	44393.	2308.	235.	-1.548	-6767.
12	145.20	0.540	-0.014	-9268.	41249.	2179.	311.	-1.660	-5549.
13	158.40	0.779	0.041	-16938.	37390.	1892.	381.	-1.768	-5037.
14	171.60	0.942	0.087	-23471.	32627.	1298.	454.	-1.890	-5270.
15	184.80	1.000	0.119	-25813.	27082.	410.	507.	-2.037	-6403.
16	198.00	0.939	0.136	-24207.	21284.	-392.	517.	-2.195	-7013.
17	211.20	0.756	0.139	-21188.	15616.	-906.	499.	-2.348	-6843.
18	224.40	0.468	0.130	-17643.	10746.	-1234.	467.	-2.493	-6579.
19	237.60	0.092	0.112	-13462.	5325.	-1439.	420.	-2.627	-6209.
20	250.80	-0.340	0.088	-6461.	1542.	-1457.	311.	-2.[illegible]	-5360.
21	264.00	-0.797	0.042	-423.	45.	-770.	113.	-2.754	-2817.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.36853 IN-LBF-SEC**2



B AND C ARE SCALED TO 1 INCH; T IS SCALED TO 10 DEG.

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OF POOR QUALITY

PAGE 8 BHC PROGRAM DF175R -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *
CYCLIC MODE OF BLADE AT 323.89 CPM
NATURAL FREQUENCY IS: 0.9997 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN VERT PLANE - RIGID BODY
MAX DEFLECTION PLANE AT -90.0 DEG

	BLADE STA IN	DEFLECTIONS IN(1) VERT	DEFLECTIONS IN(1) HORIZ	MOMENTS IN-LB(1) BEAM	MOMENTS IN-LB(1) CHORD	SHEAR FORCES LB(1) BEAM	SHEAR FORCES LB(1) CHORD	TWIST DEG(1)	TORQUE IN-LB(1)
					HUB				
1	0.0	0.000	0.000	0.	-111.	439.	-1.	0.039	0.
2	13.20	0.050	-0.000	4.	-98.	439.	-1.	0.039	0.
3	26.40	0.100	-0.000	4.	-81.	427.	-1.	0.039	0.
					** BLADE **				
3	26.40	0.100	-0.000	-16.	-80.	414.	-104.	0.039	0.
4	39.60	0.150	-0.000	-19.	-66.	391.	-94.	0.039	0.
5	52.80	0.200	-0.000	-18.	-53.	362.	-84.	0.039	300.
6	66.00	0.250	-0.000	-18.	-43.	342.	-76.	0.042	328.
7	79.20	0.300	-0.000	-19.	-38.	334.	-71.	0.046	336.
8	92.40	0.350	-0.000	-17.	-34.	326.	-67.	0.051	348.
9	105.60	0.400	-0.000	-15.	-30.	318.	-62.	0.057	363.
10	118.80	0.450	-0.000	-13.	-27.	309.	-57.	0.063	378.
11	132.00	0.500	-0.000	-9.	-25.	299.	-53.	0.071	392.
12	145.20	0.550	-0.000	-5.	-23.	289.	-48.	0.080	404.
13	158.40	0.600	-0.000	0.	-21.	276.	-44.	0.089	415.
14	171.60	0.650	-0.000	2.	-19.	255.	-38.	0.098	401.
15	184.80	0.700	-0.000	2.	-16.	225.	-32.	0.106	358.
16	198.00	0.750	-0.000	1.	-13.	198.	-26.	0.114	334.
17	211.20	0.800	-0.001	2.	-12.	180.	-22.	0.121	336.
18	224.40	0.850	-0.001	4.	-10.	164.	-19.	0.129	339.
19	237.60	0.900	-0.001	5.	-9.	148.	-16.	0.136	338.
20	250.80	0.950	-0.001	1.	-7.	109.	-11.	0.142	266.
21	264.00	1.000	-0.001	-0.	-2.	40.	-4.	0.144	98.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.23884 IN-LBF-SEC**2

PAGE 9 BHC PROGRAM DF175P -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * * *
CYCLIC MODE OF BLADE AT 453.83 CPM
NATURAL FREQUENCY IS: 1.4007 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN HORIZ PLANE - 1 NODE
MAX DEFLECTION PLANE AT -6.9 DEG

	BLADE STA IN	DEFLECTIONS IN(1) VERT	HORIZ	MOMENTS IN-LB(1) BEAM	CHORD	SHEAR FORCES LB(1) BEAM	CHORD	TWIST DEG(1)	TORQUE IN-LB(1)
					HUB				
1	0.0	-0.000	0.000	0.	124514.	-118.	947.	-0.004	0.
2	13.20	-0.028	0.003	-1641.	112401.	-118.	947.	-0.004	0.
3	26.40	-0.062	0.015	-4118.	101225.	-105.	945.	-0.004	0.
					** BLADE **				
3	26.40	-0.062	0.015	20493.	99215.	127.	942.	-0.004	0.
4	39.60	-0.095	0.037	14822.	90259.	146.	925.	-0.004	0.
5	52.80	-0.122	0.067	9935.	81978.	170.	896.	-0.004	-77.
6	66.00	-0.138	0.103	6105.	74067.	182.	871.	-0.003	-10.
7	79.20	-0.141	0.144	3569.	66472.	182.	860.	-0.002	64.
8	92.40	-0.134	0.191	2024.	59185.	179.	848.	0.001	117.
9	105.60	-0.121	0.242	1123.	52208.	176.	834.	0.003	149.
10	118.80	-0.104	0.296	605.	45544.	171.	817.	0.006	168.
11	132.00	-0.085	0.352	319.	39195.	165.	798.	0.009	180.
12	145.20	-0.065	0.411	177.	33159.	158.	776.	0.013	189.
13	158.40	-0.044	0.472	124.	27459.	150.	747.	0.018	194.
14	171.60	-0.023	0.534	92.	22215.	139.	697.	0.022	194.
15	184.80	-0.002	0.598	47.	17551.	124.	625.	0.026	182.
16	198.00	0.019	0.664	-3.	13417.	110.	559.	0.030	173.
17	211.20	0.040	0.730	-34.	9673.	98.	511.	0.034	172.
18	224.40	0.061	0.797	-42.	6257.	87.	469.	0.038	171.
19	237.60	0.081	0.864	-27.	3186.	76.	424.	0.042	169.
20	250.80	0.102	0.932	-9.	887.	58.	316.	0.045	133.
21	264.00	0.122	1.000	-1.	11.	20.	117.	0.046	49.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.19704 IN-LBF-SEC**2

PAGE 10
540015

BHC PROGRAM DF175B -COMPILED 02/25/75 02/26/75

NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74

* * * * * * * * *

CYCLIC MODE OF BLADE AT 838.14 CPM

NATURAL FREQUENCY IS: 2.5869 PER REV

15.00 DEGREE ROOT COLLECTIVE

324.00 ROTOR RPM

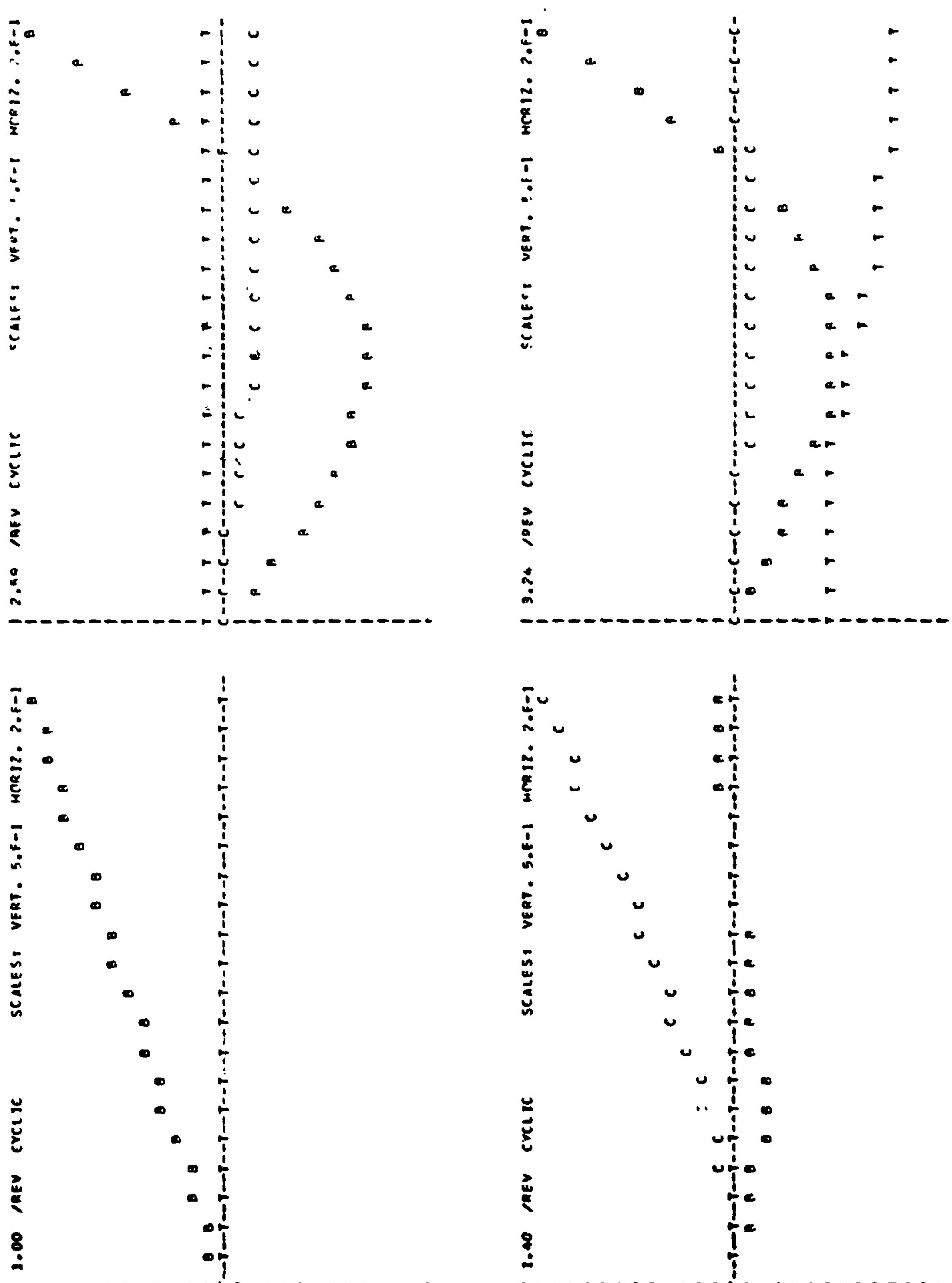
MAXIMUM AMPLITUDE IN VERT PLANE - 2 NODES

MAX DEFLECTION PLANE AT -98.6 DEG

	BLADE STA IN	DEFLECTIONS IN(1) VERT	DEFLECTIONS IN(1) HORIZ	MOMENTS IN-LB(1) BEAM	MOMENTS IN-LB(1) CHORD	SHEAR FORCES LB(1) BEAM	SHEAR FORCES LB(1) CHORD	TWIST DEG(1)	TORQUE IN-LB(1)
					HUB				
1	0.0	-0.000	-0.000	0.	-107199.	-2073.	-787.	0.634	0.
2	13.20	-0.158	-0.003	9198.	-97165.	-2073.	-787.	0.634	0.
3	26.40	-0.279	-0.013	20010.	-87986.	-1823.	-782.	0.634	0.
					** BLADE **				
3	26.40	-0.279	-0.013	-1870.	-90713.	-1958.	-318.	0.634	0.
4	39.60	-0.387	-0.031	6958.	-83959.	-1461.	-420.	0.634	0.
5	52.80	-0.489	-0.054	9447.	-77218.	-897.	-502.	0.634	2478.
6	66.00	-0.581	-0.077	8456.	-70258.	-523.	-542.	0.654	1916.
7	79.20	-0.653	-0.099	7422.	-63458.	-383.	-584.	0.676	1793.
8	92.40	-0.702	-0.119	6679.	-56845.	-250.	-561.	0.699	1647.
9	105.60	-0.730	-0.138	6191.	-50425.	-116.	-563.	0.722	1484.
10	118.80	-0.734	-0.154	5877.	-44209.	16.	-560.	0.745	1351.
11	132.00	-0.714	-0.167	5794.	-38215.	141.	-552.	0.770	1270.
12	145.20	-0.668	-0.179	6136.	-32455.	257.	-540.	0.797	1260.
13	158.40	-0.593	-0.187	6906.	-26952.	376.	-522.	0.825	1372.
14	171.60	-0.485	-0.191	7338.	-21818.	530.	-488.	0.861	1565.
15	184.80	-0.345	-0.193	6793.	-17199.	686.	-437.	0.902	1897.
16	198.00	-0.173	-0.191	5648.	-13096.	787.	-386.	0.949	2070.
17	211.20	0.028	-0.186	4508.	-9398.	819.	-346.	0.996	2131.
18	224.40	0.252	-0.179	3473.	-6048.	822.	-310.	1.044	2163.
19	237.60	0.493	-0.171	2468.	-3060.	794.	-273.	1.090	2156.
20	250.80	0.744	-0.161	1108.	-848.	652.	-197.	1.125	1793.
21	264.00	1.000	-0.152	66.	-18.	276.	-70.	1.138	747.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.26852 IN-LBF-SEC**2



B AND C ARE SCALED TO 1 INCH; T IS SCALED TO 10 DEG.

PAGE 11 BHC PROGRAM DF175B -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *
CYCLIC MODE OF BLADE AT 1048.77 CPM
NATURAL FREQUENCY IS: 3.2369 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN VERT PLANE - 2 NODES
MAX DEFLECTION PLANE AT -88.3 DEG

	BLADE STA IN	DEFLECTIONS IN(1) VERT	HORIZ	MOMENTS IN-LB(1) BEAM	CHORD	SHEAR FORCES LB(1) BEAM	CHORD	TWIST DEG(1)	TORQUE IN-LB(1)
					HUB				
1	0.0	0.000	0.000	0.	-47727.	-1048.	-207.	-4.725	0.
2	13.20	-0.083	-0.001	3726.	-45130.	-1048.	-207.	-4.725	0.
3	26.40	-0.152	-0.006	6878.	-42947.	-854.	-203.	-4.725	0.
					** BLADE **				
3	26.40	-0.152	-0.006	-3716.	-43335.	-878.	9.	-4.725	0.
4	39.60	-0.218	-0.015	-435.	-41430.	-775.	-85.	-4.725	0.
5	52.80	-0.289	-0.028	2533.	-38746.	-751.	-176.	-4.725	-26681.
6	66.00	-0.353	-0.041	3699.	-35610.	-546.	-224.	-4.978	-24705.
7	79.20	-0.411	-0.054	4236.	-32417.	-452.	-240.	-5.258	-23260.
8	92.40	-0.461	-0.066	4378.	-29213.	-368.	-282.	-5.559	-21811.
9	105.60	-0.498	-0.078	4552.	-26019.	-282.	-261.	-5.868	-20318.
10	118.80	-0.520	-0.087	4779.	-22853.	-189.	-267.	-6.199	[illegible]
11	132.00	-0.524	-0.095	5200.	-19741.	-93.	-268.	-6.542	[illegible]
12	145.20	-0.505	-0.099	6103.	-16703.	1.	-266.	-6.884	-15491.
13	158.40	-0.457	-0.099	7666.	-13763.	110.	-260.	-7.193	-13715.
14	171.60	-0.373	-0.095	8685.	-11007.	325.	-242.	-7.450	-11548.
15	184.80	-0.250	-0.085	7734.	-8546.	604.	-213.	-7.654	-9113.
16	198.00	-0.092	-0.072	5828.	-6413.	760.	-182.	-7.813	-7069.
17	211.20	0.095	-0.054	4224.	-4535.	785.	-158.	-7.935	-5407.
18	224.40	0.303	-0.035	3103.	-2868.	763.	-137.	-8.023	-3877.
19	237.60	0.527	-0.014	2482.	-1409.	704.	-115.	-8.077	-2413.
20	250.80	0.762	0.008	1367.	-366.	590.	-78.	-8.105	-1057.
21	264.00	1.000	0.030	102.	-8.	274.	-24.	-8.114	-185.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.53263 IN-LBF-SEC**2

PAGE 13 BHC PROGRAM DF175R -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *
SCISSORS MODE OF BLADE AT 337.98 CPM
NATURAL FREQUENCY IS: 1.0432 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN VERT PLANE - RIGID BODY
MAX DEFLECTION PLANE AT -87.3 DEG

	BLADE STA IN	DEFLECTIONS IN(1)		MOMENTS IN-LB(1)		SHEAR FORCES LB(1)		TWIST DEG(1)	TORQUE IN-LB(1)
		VERT	HORIZ	BEAM	CHORD	BEAM	CHORD		
					HUB				
1	0.0	0.000	-0.000	6226.	3158.	431.	30.	0.039	0.
2	13.20	0.021	0.000	3008.	2771.	431.	30.	0.039	0.
3	26.40	0.064	0.000	2189.	2415.	426.	30.	0.039	0.
					** BLADE **				
3	26.40	0.064	0.000	2708.	1814.	421.	-74.	0.039	0.
4	39.60	0.109	0.001	1989.	1676.	404.	-66.	0.039	0.
5	52.80	0.155	0.002	1349.	1547.	382.	-58.	0.039	289.
6	66.00	0.202	0.003	840.	1417.	364.	-51.	0.042	326.
7	79.20	0.252	0.005	498.	1281.	357.	-46.	0.047	345.
8	92.40	0.302	0.008	291.	1147.	350.	-42.	0.052	365.
9	105.60	0.354	0.010	169.	1016.	342.	-38.	0.058	385.
10	118.80	0.407	0.013	99.	888.	333.	-33.	0.065	404.
11	132.00	0.460	0.016	62.	766.	323.	-29.	0.073	420.
12	145.20	0.513	0.019	46.	648.	312.	-25.	0.083	435.
13	158.40	0.567	0.022	42.	536.	299.	-21.	0.093	448.
14	171.60	0.621	0.025	38.	434.	276.	-17.	0.103	434.
15	184.80	0.675	0.028	31.	343.	245.	-13.	0.111	390.
16	198.00	0.729	0.031	23.	262.	217.	-9.	0.120	365.
17	211.20	0.783	0.034	18.	187.	197.	-7.	0.128	368.
18	224.40	0.837	0.038	15.	118.	180.	-4.	0.136	371.
19	237.60	0.891	0.041	12.	56.	162.	-2.	0.144	371.
20	250.80	0.946	0.044	4.	11.	120.	-1.	0.151	292.
21	264.00	1.000	0.047	0.	-2.	44.	0.	0.153	108.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.22249 IN-LBF-SEC**2

ORIGINAL PAGE IS OF POOR QUALITY

PAGE 14 BHC PROGRAM DF175B -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *
SCISSORS MODE OF BLADE AT 457.48 CPM
NATURAL FREQUENCY IS: 1.4120 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN HORIZ PLANE - 1 NODE
MAX DEFLECTION PLANE AT -2.6 DEG

	BLADE STA IN	DEFLECTIONS IN(1) VERT	DEFLECTIONS IN(1) HORIZ	MOMENTS IN-LB(1) BEAM	MOMENTS IN-LB(1) CHORD	SHEAR FORCES LB(1) BEAM	SHEAR FORCES LB(1) CHORD	TWIST DEG(1)	TORQUE IN-LB(1)
					HUB				
1	0.0	0.000	0.000	-3752.	126636.	-134.	959.	-0.010	0.
2	13.20	-0.014	0.003	-3587.	114373.	-134.	959.	-0.010	0.
3	26.40	-0.048	0.015	-5722.	103062.	-127.	957.	-0.010	0.
					** BLADE **				
3	26.40	-0.048	0.015	19381.	101385.	108.	959.	-0.010	0.
4	39.60	-0.082	0.038	13937.	92238.	120.	943.	-0.010	0.
5	52.80	-0.110	0.068	9300.	83772.	139.	914.	-0.010	-101.
6	66.00	-0.128	0.104	5691.	75682.	150.	889.	-0.009	-37.
7	79.20	-0.134	0.146	3306.	67919.	148.	878.	-0.008	32.
8	92.40	-0.132	0.192	1855.	60472.	145.	866.	-0.006	81.
9	105.60	-0.123	0.243	1012.	53349.	142.	851.	-0.005	109.
10	118.80	-0.111	0.297	529.	46534.	137.	833.	-0.002	125.
11	132.00	-0.097	0.353	262.	40047.	131.	813.	0.000	135.
12	145.20	-0.083	0.412	130.	33880.	125.	790.	0.003	141.
13	158.40	-0.068	0.473	79.	28056.	117.	761.	0.006	144.
14	171.60	-0.053	0.535	50.	22698.	107.	710.	0.009	143.
15	184.80	-0.038	0.599	10.	17932.	96.	637.	0.012	135.
16	198.00	-0.023	0.664	-33.	13708.	84.	568.	0.015	127.
17	211.20	-0.009	0.730	-57.	9883.	74.	519.	0.018	125.
18	224.40	0.005	0.797	-60.	6393.	65.	477.	0.021	124.
19	237.60	0.019	0.865	-40.	3256.	56.	431.	0.024	121.
20	250.80	0.033	0.932	-14.	907.	40.	321.	0.026	95.
21	264.00	0.046	1.000	-2.	12.	14.	119.	0.027	35.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.19501 IN-LBF-SEC**2

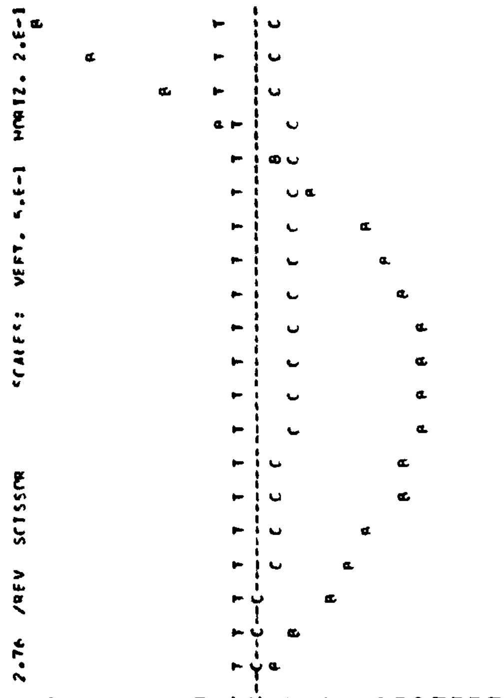
PAGE 15 BHC PROGRAM DF175R -COMPILED 02/25/75 02/26/75
540015 NATURAL BLADE MODES

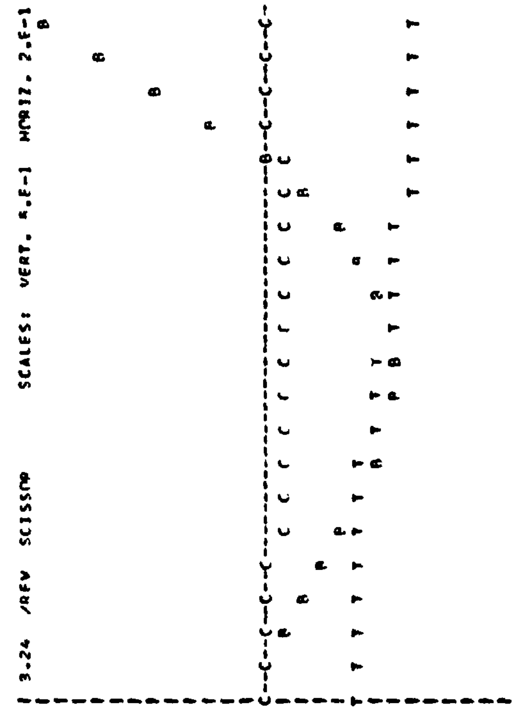
BASELINE 540 ROTOR, 12-03-74
* * * * * * * * *
SCISSORS MODE OF BLADE AT 893.98 CPM
NATURAL FREQUENCY IS: 2.7592 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN VERT PLANE - 2 NODES
MAX DEFLECTION PLANE AT -94.7 DEG

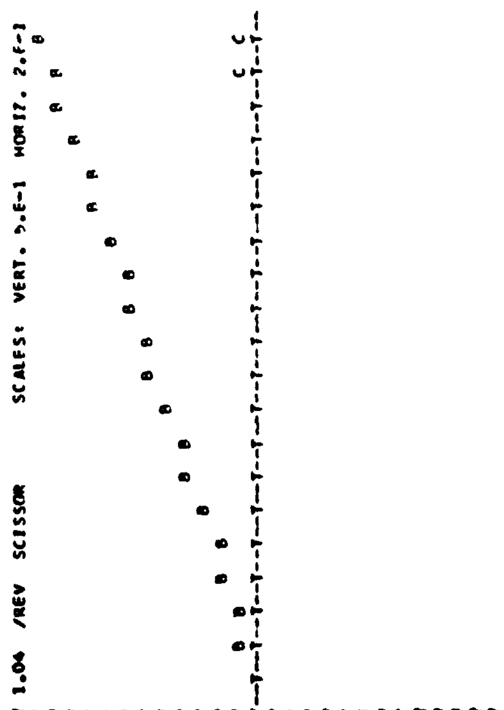
	BLADE STA IN	DEFLECTIONS IN(1) VERT	HORIZ	MOMENTS IN-LB(1) BEAM	CHORD	SHEAR FORCES LB(1) BEAM	CHORD	TWIST DEG(1)	TORQUE IN-LB(1)
					HUB				
1	0.0	-0.000	0.000	-22610.	-96820.	-2089.	-749.	0.733	0.
2	13.20	-0.073	-0.003	-3429.	-87236.	-2089.	-749.	0.733	0.
3	26.40	-0.193	-0.012	9285.	-78442.	-1957.	-744.	0.733	0.
					** BLADE **				
3	26.40	-0.193	-0.012	-9967.	-78358.	-2079.	-249.	0.733	0.
4	39.60	-0.309	-0.028	782.	-73034.	-1673.	-328.	0.733	0.
5	52.80	-0.424	-0.050	5371.	-67301.	-1144.	-400.	0.733	3090.
6	66.00	-0.532	-0.072	6107.	-61335.	-771.	-440.	0.758	2425.
7	79.20	-0.626	-0.094	6280.	-55468.	-626.	-454.	0.784	2228.
8	92.40	-0.701	-0.115	6342.	-49736.	-481.	-464.	0.811	2007.
9	105.60	-0.755	-0.133	6389.	-44148.	-331.	-469.	0.837	1773.
10	118.80	-0.786	-0.149	6444.	-38719.	-177.	-470.	0.864	1575.
11	132.00	-0.790	-0.162	6648.	-33468.	-26.	-466.	0.892	1443.
12	145.20	-0.764	-0.172	7281.	-28409.	116.	-458.	0.921	1400.
13	158.40	-0.704	-0.177	8386.	-23565.	268.	-442.	0.952	1451.
14	171.60	-0.605	-0.178	9046.	-19036.	477.	-415.	0.992	1745.
15	184.80	-0.465	-0.173	8453.	-14963.	688.	-370.	1.041	2177.
16	198.00	-0.286	-0.165	7071.	-11356.	830.	-325.	1.094	2403.
17	211.20	-0.071	-0.152	5667.	-8120.	892.	-289.	1.149	2469.
18	224.40	0.172	-0.137	4383.	-5202.	908.	-257.	1.204	2499.
19	237.60	0.437	-0.119	3130.	-2614.	887.	-223.	1.257	2482.
20	250.80	0.716	-0.101	1415.	-716.	738.	-158.	1.297	2075.
21	264.00	1.000	-0.082	85.	-15.	319.	-55.	1.312	876.

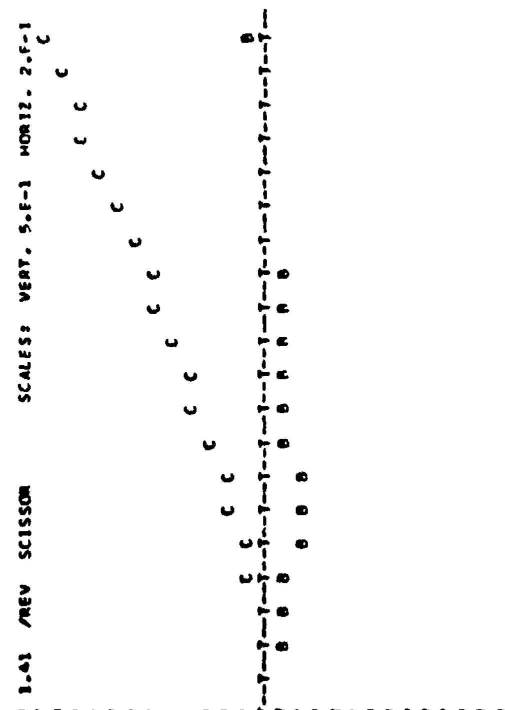
NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.25309 IN-LBF-SEC**2









B AND C ARE SCALED TO 1 INCH; T IS SCALED TO 10 DEG.

PAGE 16 BHC PROGRAM DF1758 -COMPILED 02/25/75 07/26/75
540015 NATURAL BLADE MODES

BASELINE 540 ROTOR, 12-03-74
* * * * * * * *
SCISSORS MODE OF BLADE AT 1048.32 CPM
NATURAL FREQUENCY IS: 3.2356 PER REV
15.00 DEGREE ROOT COLLECTIVE
324.00 ROTOR RPM
MAXIMUM AMPLITUDE IN VERT PLANE - 2 NODES
MAX DEFLECTION PLANE AT -87.7 DEG

	BLADE STA IN	DEFLECTIONS IN(1)		MOMENTS IN-LB(1)		SHEAR FORCES LB(1)		TWIST DEG(1)	TORQUE IN-LB(1)
		VERT	HORIZ	BEAM	CHORD	BEAM	CHORD		
					HUB				
1	0.0	0.000	0.000	-11728.	-48375.	-1043.	-264.	-3.789	0.
2	13.20	-0.040	-0.001	-3084.	-45026.	-1043.	-264.	-3.789	0.
3	26.40	-0.111	-0.006	1282.	-42097.	-952.	-260.	-3.789	0.
					** BLADE **				
3	26.40	-0.111	-0.006	-8940.	-41156.	-986.	-22.	-3.789	0.
4	39.60	-0.183	-0.015	-4159.	-39116.	-931.	-90.	-3.785	0.
5	52.80	-0.262	-0.028	29.	-36512.	-892.	-163.	-3.785	-21440.
6	66.00	-0.337	-0.042	2184.	-33540.	-693.	-204.	-3.993	-19921.
7	79.20	-0.409	-0.057	3445.	-30515.	-598.	-219.	-4.220	-18791.
8	92.40	-0.475	-0.071	4121.	-27880.	-506.	-232.	-4.464	-17657.
9	105.60	-0.528	-0.084	4656.	-24455.	-408.	-241.	-4.716	-16487.
10	118.80	-0.566	-0.095	5133.	-21457.	-300.	-247.	-4.985	-15261.
11	132.00	-0.584	-0.104	5738.	-18511.	-186.	-2[illegible]9.	-5.265	-13576.
12	145.20	-0.577	-0.109	6805.	-15635.	-72.	-248.	-5.544	-12609.
13	158.40	-0.537	-0.110	8514.	-12851.	61.	-242.	-5.795	-11129.
14	171.[illegible]0	-0.458	-0.105	9636.	-10240.	300.	-225.	-6.001	-9249.
15	184.80	-0.336	-0.094	8753.	-7921.	603.	-197.	-6.159	-7092.
16	198.00	-0.173	-0.079	6825.	-5918.	784.	-167.	-6.279	-5321.
17	211.20	0.023	-0.059	5121.	-4164.	830.	-143.	-6.368	-3923.
18	224.40	0.246	-0.036	3840.	-2617.	825.	-122.	-6.428	-2645.
19	237.60	0.487	-0.012	2978.	-1271.	777.	-101.	-6.461	-1433.
20	250.80	0.741	0.014	1558.	-323.	657.	-66.	-6.475	-391.
21	264.00	1.000	0.040	111.	-7.	[illegible]03.	-19.	-6.479	60.

NOTE (1) PER INCH MAX DEFLECTION

THE GENERALIZED INERTIA IS 0.40002 IN-LBF-SEC**2

PAGE 18 BHC PROGRAM DF175P -COMPILED 02/25/75 02/26/75

NATURAL BLADE MODES

540015 BASELINE 540 ROTOR, 12-03-74 * * * * * * * * *

COLLECTIVE MODE

NATURAL FREQ /REV	ROOT COLL DEG	ROTOR RPM	MAXIMUM AMPLITUDE	NUMBER OF NODES	MAX DEFLECTION ANGLE--DEG
1.04573	10.0	310.0	VERT PLANE	1 NODE	-89.8
2.68450	10.0	310.0	VERT PLANE	2 NODES	-84.7
3.36139	10.0	310.0	VERT PLANE	2 NODES	-86.7
4.69991	10.0	310.0	VERT PLANE	3 OR MORE	-88.2
1.04357	10.0	324.0	VERT PLANE	1 NODE	-89.8
2.65851	10.0	324.0	VERT PLANE	2 NODES	-84.6
3.23995	10.0	324.0	VERT PLANE	2 NODES	-86.5
4.61627	10.0	324.0	VERT PLANE	3 OR MORE	-88.3
1.04165	10.0	338.0	VERT PLANE	1 NODE	-89.8
2.63260	10.0	338.0	VERT PLANE	2 NODES	-84.4
3.13128	10.0	338.0	VERT PLANE	2 NODES	-86.2
4.54070	10.0	338.0	VERT PLANE	3 OR MORE	-88.4
1.04578	15.0	310.0	VERT PLANE	1 NODE	-89.7
2.67497	15.0	310.0	VERT PLANE	2 NODES	-79.0
3.35621	15.0	310.0	VERT PLANE	2 NODES	-81.4
4.68663	15.0	310.0	VERT PLANE	3 OR MORE	-83.2
1.04361	15.0	324.0	VERT PLANE	1 NODE	-89.7
2.64905	15.0	324.0	VERT PLANE	2 NODES	-78.9
3.23455	15.0	324.0	VERT PLANE	2 NODES	-81.1
4.60353	15.0	324.0	VERT PLANE	3 OR MORE	-83.2
1.04168	15.0	338.0	VERT PLANE	1 NODE	-89.8
2.62321	15.0	338.0	VERT PLANE	2 NODES	-78.8
3.12565	15.0	338.0	VERT PLANE	2 NODES	-80.8
4.52846	15.0	338.0	VERT PLANE	3 OR MORE	-83.3
1.04585	20.0	310.0	VERT PLANE	1 NODE	-89.6
2.65947	20.0	310.0	VERT PLANE	2 NODES	-73.3
3.34698	20.0	310.0	VERT PLANE	2 NODES	-76.1
4.66865	20.0	310.0	VERT PLANE	3 OR MORE	-78.1

540015 BASELINE 540 ROTOR, 12-03-74 * * * * * * * * *

CYCLIC MODE

NATURAL FREQ /REV	ROOT COLL DEG	ROTOR RPM	MAXIMUM AMPLITUDE	NUMBER OF NODES	MAX DEFLECTION ANGLE--DEG
0.99970	10.0	310.0	VERT PLANE	RIGID BODY	-90.0
1.54351	10.0	310.0	HORIZ PLANE	1 NODE	-5.0
2.52972	10.0	310.0	VERT PLANE	2 NODES	-98.2
3.36410	10.0	310.0	VERT PLANE	2 NODES	-90.2
4.41313	10.0	310.0	VERT PLANE	3 OR MORE	-89.2
0.99965	10.0	324.0	VERT PLANE	RIGID BODY	-90.0
1.48515	10.0	324.0	HORIZ PLANE	1 NODE	-4.4
2.50591	10.0	324.0	VERT PLANE	2 NODES	-97.3
3.24131	10.0	324.0	VERT PLANE	2 NODES	-90.6
4.34007	10.0	324.0	VERT PLANE	3 OR MORE	-89.0
0.99968	10.0	338.0	VERT PLANE	RIGID BODY	-90.1
1.43128	10.0	338.0	HORIZ PLANE	1 NODE	-3.9
2.48493	10.0	338.0	VERT PLANE	2 NODES	-96.5
3.13034	10.0	338.0	VERT PLANE	2 NODES	-90.8
4.27477	10.0	338.0	VERT PLANE	3 OR MORE	-88.8
0.99967	15.0	310.0	VERT PLANE	RIGID BODY	-90.0
1.45015	15.0	310.0	HORIZ PLANE	1 NODE	-7.7
2.61831	15.0	310.0	VERT PLANE	2 NODES	-99.6
3.35898	15.0	310.0	VERT PLANE	2 NODES	-87.6
4.46275	15.0	310.0	VERT PLANE	3 OR MORE	-84.5
0.99966	15.0	324.0	VERT PLANE	RIGID BODY	-90.0
1.40070	15.0	324.0	HORIZ PLANE	1 NODE	-[illegible].9
2.58685	15.0	324.0	VERT PLANE	2 NODES	-96.6
3.23695	15.0	324.0	VERT PLANE	2 NODES	-88.3
4.28502	15.0	324.0	VERT PLANE	3 OR MORE	-84.3
0.99964	15.0	338.0	VERT PLANE	RIGID BODY	-90.0
1.35460	15.0	338.0	HORIZ PLANE	1 NODE	-6.3
2.55715	15.0	338.0	VERT PLANE	2 NODES	-97.8
3.12703	15.0	338.0	VERT PLANE	2 NODES	-88.8
4.31549	15.0	338.0	VERT PLANE	3 OR MORE	-84.0
0.99962	20.0	310.0	VERT PLANE	RIGID BODY	-90.0
1.34509	20.0	310.0	HORIZ PLANE	1 NODE	-8.8
2.72129	20.0	310.0	VERT PLANE	2 NODES	-97.7
3.35058	20.0	310.0	VERT PLANE	2 NODES	-84.6
4.52027	20.0	310.0	VERT PLANE	3 OR MORE	-79.8

PAGE 19 BHC PROGRAM DF175B -COMPILED 02/25/75 07/24/75

NATURAL BLADE MODES

540015 BASELINE 540 ROTOR, 12-03-74

COLLECTIVE MODE

NATURAL FREQ /REV	ROOT COLL DEG	ROTOR RPM	MAXIMUM AMPLITUDE	NUMBER OF NODES	MAX DEFLECTION ANGLE--DEG
1.04366	20.0	324.0	VERT PLANE	1 NODE	-89.7
2.63367	20.0	324.0	VERT PLANE	2 NODES	-73.2
3.22491	20.0	324.0	VERT PLANE	2 NODES	-75.7
4.58625	20	324.0	VERT PLANE	3 OR MORE	-78.2
1.04172	20.0	338.0	VERT PLANE	1 NODE	-89.7
2.60795	20.0	338.0	VERT PLANE	2 NODES	-73.1
3.11562	20.0	338.0	VERT PLANE	2 NODES	-75.4
4.51185	20.0	328.0	VERT PLANE	3 OR MORE	-78.2

540015 BASELINE 540 ROTOR, 12-03-74

CYCLIC MODE

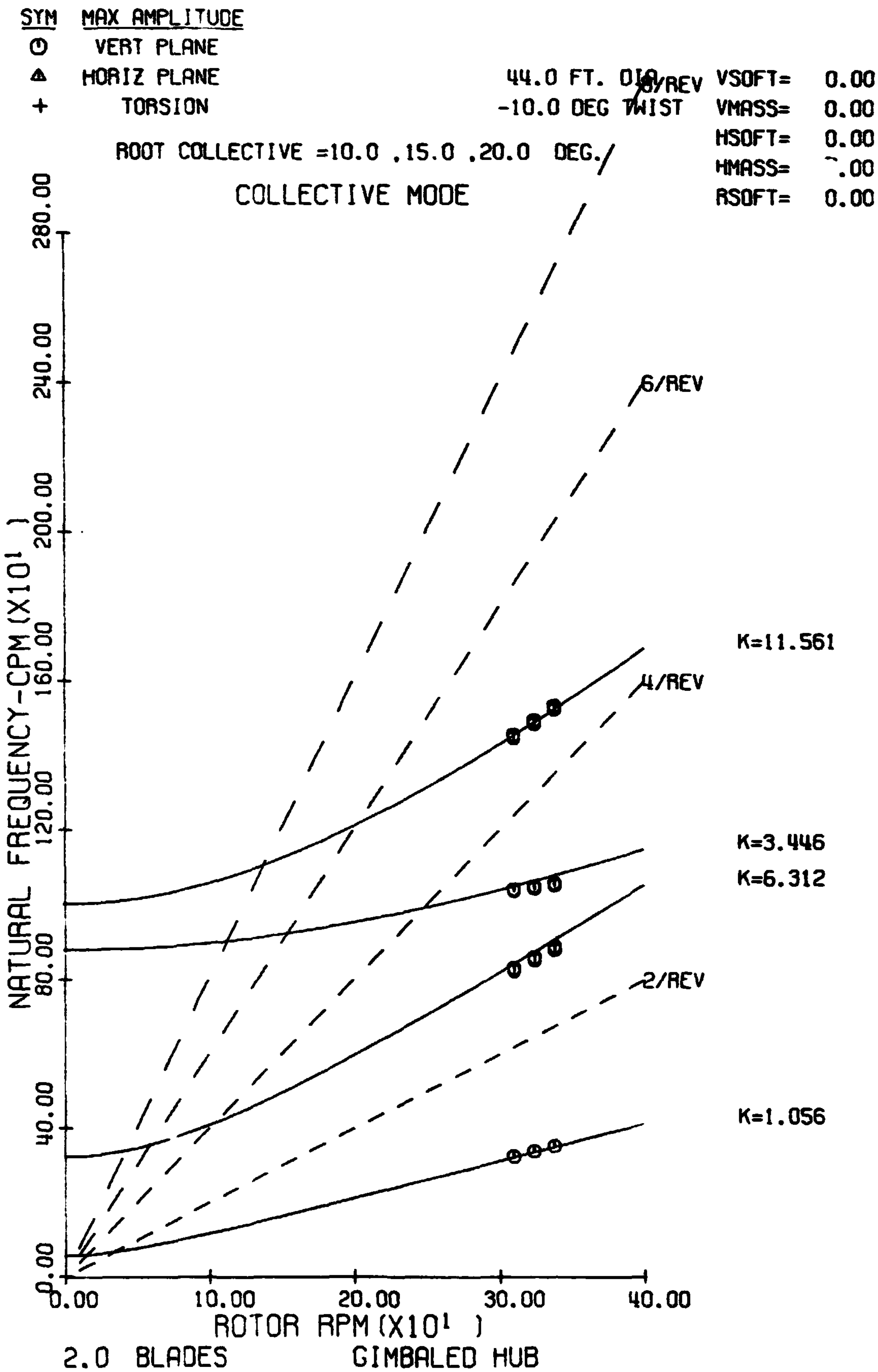
NATURAL FREQ /REV	ROOT COLL DEG	ROTOR RPM	MAXIMUM AMPLITUDE	NUMBER OF NODES	MAX DEFLECTION ANGLE--DEG
0.99961	20.0	324.0	VERT PLANE	RIGID BODY	-90.0
1.30396	20.0	324.0	HORIZ PLANE	1 NODE	-8.1
2.68129	20.0	324.0	VERT PLANE	2 NODES	-97.0
3.22983	20.0	324.0	VERT PLANE	2 NODES	-85.5
4.43661	20.0	324.0	VERT PLANE	3 OR MORE	-79.4
0.99949	20.0	338.0	VERT PLANE	RIGID BODY	-90.0
1.26535	20.0	338.0	HORIZ PLANE	1 NODE	-7.4
2.64304	20.0	338.0	VERT PLANE	2 NODES	-96.4
3.12182	20.0	338.0	VERT PLANE	2 NODES	-86.3
4.36176	20.0	338.0	VERT PLANE	3 OR MORE	-79.1

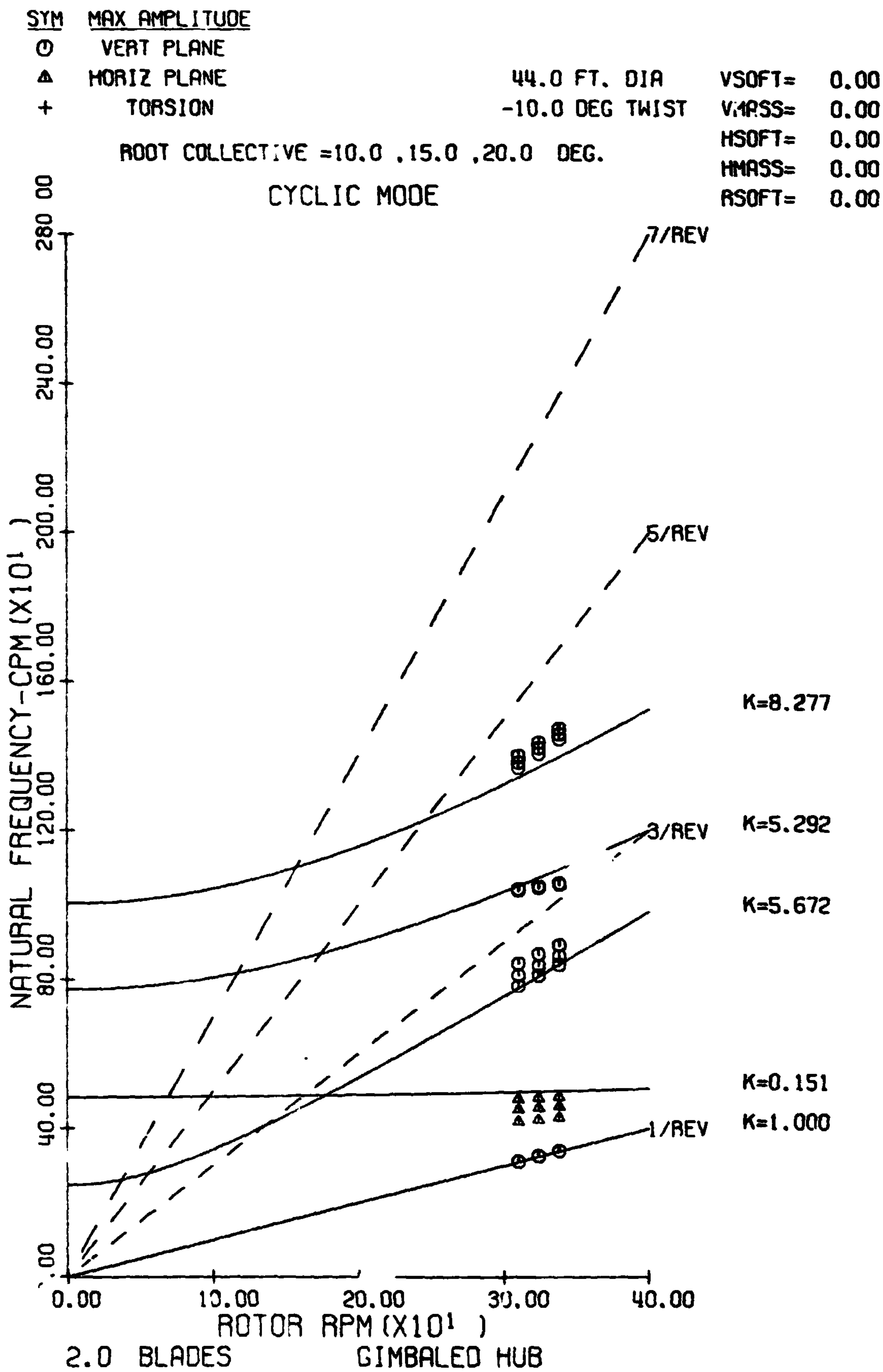
ORIGINAL PAGE IS OF POOR QUALITY

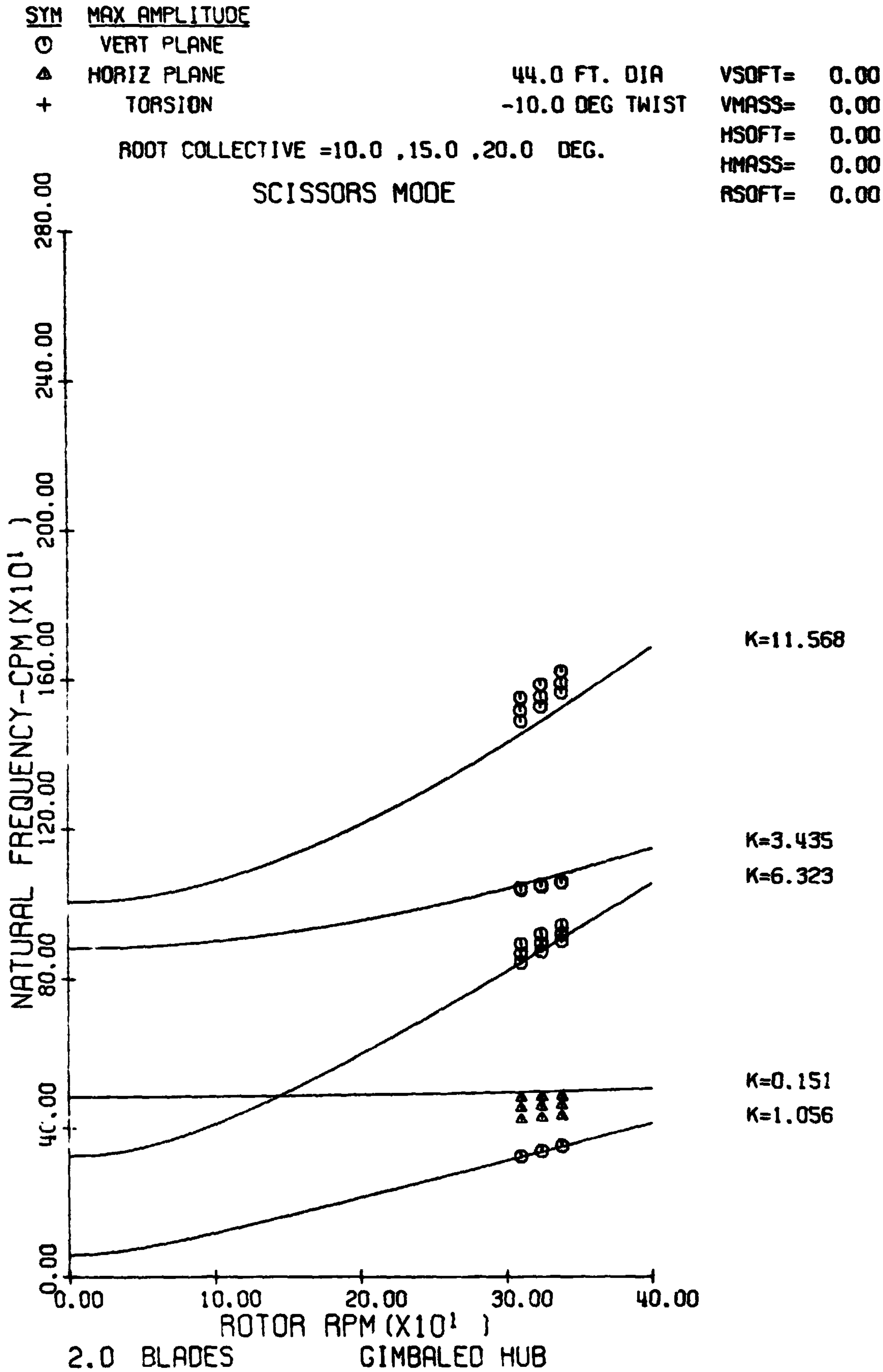
PAGE 19   BHC PROGRAM DF175P -COMPILED 02/25/75   02/26/75
NATURAL BLADE MODES

540015   BASELINE 540 ROTOR, 12-03-74

NATURAL FREQ /REV	ROOT COLL DEG	SCISSORS ROTOR RPM	MODE MAXIMUM AMPLITUDE	NUMBER OF NODES	MAX DEFLECTION ANGLE--DEG
1.04559	10.0	310.0	VERT PLANE	RIGID BODY	-88.6
1.55024	10.0	310.0	HORIZ PLANE	1 NODE	-2.0
2.72346	10.0	310.0	VERT PLANE	2 NODES	-94.9
3.36064	10.0	310.0	VERT PLANE	2 NODES	-89.[illegible]
4.80779	10.0	310.0	VERT PLANE	3 OR MORE	-89.4
1.04343	10.0	324.0	VERT PLANE	RIGID BODY	-88.6
1.4905[illegible]	10.0	324.0	HORIZ PLANE	1 NODE	-1.6
2.69393	10.0	324.0	VERT PLANE	2 NODES	-94.4
3.23960	10.0	324.0	VERT PLANE	2 NODES	-90.1
4.71805	10.0	324.0	VERT PLANE	3 OR MORE	-89.2
1.04151	10.0	338.0	VERT PLANE	RIGID BODY	-88.5
1.43566	10.0	338.0	HORIZ PLANE	1 NODE	-1.3
2.66469	10.0	338.0	VERT PLANE	2 NODES	-94.0
3.13160	10.0	338.0	VERT PLANE	2 NODES	-90.4
4.63700	10.0	338.0	VERT PLANE	3 OR MORE	-89.0
1.04531	15.0	310.0	VERT PLANE	RIGID BODY	-87.3
1.46383	15.0	310.0	HORIZ PLANE	1 NODE	-3.2
2.79575	15.0	310.0	VERT PLANE	2 NODES	-95.2
3.35548	15.0	310.0	VERT PLANE	2 NODES	-87.1
4.89655	15.0	310.0	VERT PLANE	3 OR MORE	-84.6
1.04315	15.0	324.0	VERT PLANE	RIGID BODY	-87.3
1.41197	15.0	324.0	HORIZ PLANE	1 NODE	-2.6
2.75919	15.0	324.0	VERT PLANE	2 NODES	-94.7
3.23556	15.0	324.0	VERT PLANE	2 NODES	-87.7
4.79933	15.0	324.0	VERT PLANE	3 OR MORE	-84.3
1.04123	15.0	338.0	VERT PLANE	RIGID BODY	-87.2
1.36395	15.0	338.0	HORIZ PLANE	1 NODE	-2.1
2.72296	15.0	338.0	VERT PLANE	2 NODES	-94.2
3.12936	15.0	338.0	VERT PLANE	2 NODES	-88.2
4.71150	15.0	338.0	VERT PLANE	3 OR MORE	-84.1
1.04480	20.0	310.0	VERT PLANE	RIGID BODY	-85.7
1.36325	20.0	310.0	HORIZ PLANE	1 NODE	-2.8
2.88056	20.0	310.0	VERT PLANE	2 NODES	-[illegible].9
3.34714	20.0	310.0	VERT PLANE	2 NODES	-84.0
5.00752	20.0	310.0	VERT PLANE	3 OR MORE	-79.6
1.04261	20.0	324.0	VERT PLANE	RIGID BODY	-85.5
1.3193	20.0	324.0	HORIZ PLANE	1 NODE	-2.1
2.83616	20.0	324.0	VERT PLANE	2 NODES	-97.5
3.22929	20.0	324.0	VERT PLANE	2 NODES	-84.8
4.90055	20.0	324.0	VERT PLANE	3 OR MORE	-79.3
1.04065	20.0	338.0	VERT PLANE	RIGID BODY	-85.3
1.27843	20.0	338.0	HORIZ PLANE	1 NODE	-1.3
2.79116	20.0	338.0	VERT PLANE	2 NODES	-97.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]


SYM MAX AMPLITUDE
VERT PLANE
HORIZ PLANE
TORSION
44.0 FT. DIA
-10.0 DEG TWIST
ROOT COLLECTIVE =10.0 ,15.0 ,20.0 DEG.
COLLECTIVE MODE
VSOFT= 0.00
VMASS= 0.00
HSOFT= 0.00
HMASS=
RSOFT= 0.00
8/REV
6/REV
4/REV
2/REV
K=11.561
K=3.446
K=6.312
K=1.056
NATURAL FREQUENCY-CPM (X10¹)
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
0.00
10.00
20.00
30.00
40.00
ROTOR RPM (X10¹)
2.0 BLADES GIMBALED HUB


SYM MAX AMPLITUDE
VERT PLANE
HORIZ PLANE
TORSION
44.0 FT. DIA
-10.0 DEG TWIST
VSOFT= 0.00
VMASS= 0.00
HSOFT= 0.00
HMASS= 0.00
RSOFT= 0.00
ROOT COLLECTIVE =10.0 ,15.0 ,20.0 DEG.
CYCLIC MODE
7/REV
5/REV
3/REV
1/REV
K=8.277
K=5.292
K=5.672
K=0.151
K=1.000
NATURAL FREQUENCY-CPM (X10¹)
ROTOR RPM (X10¹)
0.00
10.00
20.00
30.00
40.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
2.0 BLADES
GIMBALED HUB


SYM MAX AMPLITUDE
VERT PLANE
HORIZ PLANE
TORSION
44.0 FT. DIA
-10.0 DEG TWIST
VSOFT= 0.00
VMASS= 0.00
HSOFT= 0.00
HMASS= 0.00
RSOFT= 0.00
ROOT COLLECTIVE =10.0 ,15.0 ,20.0 DEG.
SCISSORS MODE
NATURAL FREQUENCY-CPM (X10¹)
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
K=11.568
K=3.435
K=6.323
K=0.151
K=1.056
0.00
10.00
20.00
30.00
40.00
ROTOR RPM (X10¹)
2.0 BLADES
GIMBALED HUB

APPENDIX C
PROGRAM LISTING

OS/360 FORTRAN H

```
OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
          SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,N EDIT,ID,XREF
      COMMON /COMA/ JHUB, N1,      LCT,POUT,ITLE(19),NAME(2),ND(2),NPG
     *,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41),INPUN
      COMMON /COMB/ CK, IRCOL, XRCOL(10), IBOM, RBOM(10) ,
     * SMZ(41), ZBAR(40), EYEB(120),
     * EYEC(120),SB(40), SC(40), VMB(40), VMC(40), VFB(40), VFC(40),
     * DFB(40), DFC(40), TH(41), THE(40), WT(40), SM(42),ISUM,XQSOM(200)
     *,AZBAR,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC,CHORD
     *,RB(41),RC(41)
      COMMON /COMC/ N,IER(7),OFFSET
      COMMON /COMD/ CMAT(5,5),SOMNAT(200,3),IPLN(200,3),INODE(200,3),
     1 MM3,MM4,MM5,CT(41), ST(41), IB ,IST,
     2   IBS(10,10,3),IBE(10,10,3),ISTS(10,3),ISTE(10,3)
      COMMON/H/ VLX(40), VDX(40), VLY(40), VMX(40), VOX(40), VMY(40),
     *          DPLX(40),DPDX(40),DPLY(40),DPMX(40),DPOX(40),DPMY(40),
     *          DFLX(40),DFDX(40),DFLY(40),VFLX(40),VFDX(40),VFLY(40),
     * F(41), BOMS, DTX(41), DTY(41), SX(41), SY(41), EMRX(41),
     * EMRY(41), EMBBW(41), EMBBO(41), EMBPO(41), EMPPW(41), EMPPO(41),
     * THHO(41), FTX(41), FTY(41), WFL(41), WFD(41), FMPPW(41)
      COMMON /COMI/ DET,MSZ, IGOOFD , SOM, OVRG
      COMMON /COMT/ EYX(41), EYB(41), EYC(41), YB(41), YC(41), XIMI(41),
     * XIT(41), EYR(41), EMRB(41), EMRC(41), EMRR(41), EMPSO(41), CCO2
     *,OVPLT,OVLIN,SVLIN
     *,       BLADES,HUBTYP
C         REAL *8 SPECIFICATION FOR IBM; COMMENTED FOR CDC VERSION.
      REAL *8  CMAT
      LOGICAL  LOT, DET , LGP1, LGP2, OVRG, CCO2, SVLIN
     1,FIRST
     1,OFFSET
      DIMENSION PP(200,3), IN(3), PQ(5,1), SQ(5), QQ(5), TOMNAT(50),
     * SMZRX(41), SMZRY(41)
      DIMENSION AA(17)
      EXTERNAL ABDUMP
      CALL ERRSET( 207,0,0,0,ABDUMP,0)
      CALL ERRSET( 208,0,0,0,ABDUMP,0)
      CALL ERRSET( 209,0,0,0,ABDUMP,0)
      CALL ERRSET( 251,0,0,0,ABDUMP,0)
      TYCE = 0.0
      CVRPS=0.1047198
      READ (5,1) AA
      WRITE (6,2)
    1 FORMAT (17A4)
    2 FORMAT (1H1)
      DO 3 I=1,6
    3 WRITE (6,4) AA
    4 FORMAT  (17X, 17A4 //////// )
      LOT = .FALSE.
   10 CALL INPT(TYCE,FIRST)
      IF (TYCE .NE. 0.0) GO TO 1000
      MM3 =3
      MM4 =4
      MM5 =5
      IF(.NOT.CCO2) GO TO 20
      MM3 =2
      MM4 =3
      MM5 =4
   20 NOB =1
```

```
      IN(1)=0
      IN(2)=0
      IN(3)=0
C*************************
C COLLECTIVE ANGLE SWEEP *------------------------------------------
C*************************
      DO 700 IST=1,IRCOL
C*****************************************************
C CALCULATE COEFFICIENTS DEPENDENT ON COLLECTIVE ANGLE *
C*****************************************************
      ISTS(IST,1)=IN(1)+1
      ISTS(IST,2)=IN(2)+1
      ISTS(IST,3)=IN(3)+1
      DO 80 I=NOB,N1
      ZTH=TH(I)
      IF(I.GT.JHUB) ZTH=ZTH+XRCOL(IST)
      ST(I)=SIN(ZTH)
      CT(I)=COS(ZTH)
      SS   ST(I)**2
      CCT. 1.-SSTH
      SCTH=ST(I)*CT(I)
      EMRX(I)=EMRC(I)*CT(I)+EMRB(I)*ST(I)
      EMRY(I)=EMRC(I)*ST(I)-EMRB(I)*CT(I)
      EMBBW(I)=YC(I)*CCTH+YB(I)*SSTH
      EMBBO(I)=(EYB (I)-EYX(I))*CCTH**2+(EYC (I)-EYX(I))*SSTH**2
      EMBPW(I)=-XIMI(I)*SCTH
      EMBPO(I)=(EYB(I)-EYX(I))*CCTH+(EYX(I)-EYC(I))*SSTH
      IF(SVLIN)  EMBPO(I)=0.
      EMPPW(I)= YB(I)*CCTH+ YC(I)*SSTH
      EMPPO(I)=XIT(I)*SCTH**2
      THHO(I)=(EMRSO(I)+XIMI(I))*(SSTH-CCTH)-EMRR(I)*SCTH
      IF(I.EQ.N1) GO TO 80
      ZTH=THE(I)
      IF(I.GT.JHUB) ZTH=ZTH+XRCOL(IST)
      STH=SIN(ZTH)
      CTH=COS(ZTH)
      SSTH=STH**2
      CCTH=1.-SSTH
      SCTH=STH*CTH
      SX(I)=0.
      SY(I)=0.
      IF(SVLIN)  GO TO 30
      SX(I)=SC(I)*CTH+SB(I)*STH
      SY(I)=SC(I)*STH-SB(I)*CTH
 30   DTX(I)=SY(I)*WT(I)
      DTY(I)=SX(I)*WT(I)
      VLX(I)=SCTH*(VFB(I)-VFC(I))
      VDX(I)=VFB(I)*SSTH+VFC(I)*CCTH
      VLY(I)=VFB(I)*CCTH+VFC(I)*SSTH
      VMX(I)=SCTH*(VMB(I)-VMC(I))
      VQX(I)=VMB(I)*SSTH+VMC(I)*CCTH
      VMY(I)=VMB(I)*CCTH+VMC(I)*SSTH
      DPLX(I)=SCTH*(DFB(I)-DFC(I))+SX(I)*DTX(I)-ZBAR(I)*VLX(I)
      DPDX(I)=DFB(I)*SSTH+DFC(I)*CCTH+SY(I)*DTX(I)-ZBAR(I)*VDX(I)
      DPLY(I)=DFB(I)*CCTH+DFC(I)*SSTH+SX(I)*DTY(I)-ZBAR(I)*VLY(I)
      DPMX(I)=VLX(I)-ZBAR(I)*VMX(I)
      DPQX(I)=VDX(I)-ZBAR(I)*VQX(I)
      DPMY(I)=VLY(I)-ZBAR(I)*VMY(I)
```

```
 80   CONTINUE
      SMZRX(N1)=0.
      SMZRY(N1)=0.
      J=N1
      DO 85 I=1,N
      K=J
      J=J-1
      SMZRX(J)=SMZRX(K)+EMRX(K)*Z(K)
 85   SMZRY(J)=SMZRY(K)+EMRY(K)*Z(K)
      NOB=JHUB+1
C******************
C ROTOR RPM SWEEP *----------------------------------------------------
C******************
      DO 710 IB= 1,IBOM
C**********************************************
C CALCULATE COEFFICIENTS DEPENDENT ON ROTOR RPM *
C**********************************************
      FIRST=.TRUE.
      BOMS=RBOM(IB)**2
      IBS(IST,IB,1)=IN(1)+1
      IBS(IST,IB,2)=IN(2)+1
      IBS(IST,IB,3)=IN(3)+1
      DO 110 I=1,N
      F(I)=BOMS*SMZ(I)
      FTX(I)=BOMS*SMZRX(I)
      FTY(I)=BOMS*SMZRY(I)
      WFL(I)=F(I)*DTY(I)
      WFD(I)=F(I)*DTX(I)
      DFLX(I)=F(I)*DPLX(I)
      DFDX(I)=F(I)*DPDX(I)-ZBAR(I)
      DFLY(I)=F(I)*DPLY(I)-ZBAR(I)
      VFLX(I)=F(I)*VLX(I)
      VFDX(I)=F(I)*VDX(I)
 110  VFLY(I)=F(I)*VLY(I)
      DET =.TRUE.
      MSZ=MM5
C************************
C CALCULATE DETERMINANTS *
C************************
      CALL COEF(1,3,.FALSE.,ISOM,XQSOM,PP)
C*************************************
C MODE(COLLECTIVE,CYCLIC,SCISSORS) SWEEP *-----------------------------
C*************************************
      DO 320 I=1,3
      IF (OFFSET.AND.I.EQ.2) GO TO 320
C********************************
C CHECK FOR DETERMINANT SIGN CHANGE *
C********************************
      LGP1=PP(1,I).GT.0.
      DO 120 J=2,ISOM
      LGP2=LGP1
      LGP1=PP(J,I).GT.0.
      IF((LGP1.AND.LGP2).OR..NOT.(LGP1.OR.LGP2))  GO TO 120
      CALL ITER(I,XQSOM(J-1),XQSOM(J),PP(J-1,I),PP(J,I))
      IF(.NOT.OVRG) GO TO 120
      IN(I)=IN(I)+1
      INI = IN(I)
      SOMNAT(INI  ,I)=SOM
```

```
  120 CONTINUE
C     GO TO 320
C CHECK FOR MISSED ROOTS *
C*************************
      KNT=0
      IF(IBS(IST,IB,I).GT.IN(I))GO TO 320
      SMEAN=.5*(XQSOM(1)+XQSOM(ISOM))
      J1=IBS(IST,IB,I)
      J2=IN(I)
      DO 130 K=1,ISOM
      DO 130 J=J1,J2
  130 PP(K,I)=PP(K,I)/ABS(XQSOM(K)  -SOMNAT(J,I))*ABS(SMEAN-SOMNAT(J,I))
      K1=1
      K2=ISOM-1
  140 PF=SIGN(1.,PP(K1,I))
      K1=K1+1
      IF(K1.GT.K2) GO TO 270
      IF(PF*PP(K1,I).LT.0.) GO TO 140
      DO 265 J=K1,K2
      IF(PF*PP(J+1,I).GT.0.) GO TO 150
      K1=J+1
      GO TO 140
  150 IF(ABS(PP(J,I)).GT.ABS(PP(J-1,I)).OR.ABS(PP(J,I)).GT.ABS(PP(J+1,I)
     *)) GO TO 265
      L1=J-2
      DO 160 K=3,5
      L1=L1+1
      PQ(K,1)=PP(L1,I)*PF
  160 SQ(K)=XQSOM(L1)
      ICK=0
  170 DO 180 K=1,2
  180 SQ(K)=.5*(SQ(K+2)+SQ(K+3))
      CALL COEF(I,I,.FALSE.,2,SQ,PQ)
      DO 190 L=1,2
      QQ(L)=PQ(L,1)*PF
      DO 190 K=J1,J2
  190 QQ(L)=QQ(L)/ABS(SQ(L)-SOMNAT(K,I))*ABS(SMEAN-SOMNAT(K,I))
      DO 200 K=1,2
      IF(QQ(K)    .LT.0.) GO TO 230
  200 CONTINUE
      ICK=ICK+1
      IF(ICK.LE.10)  GO TO 205
      WRITE(6,911)
  911 FORMAT ( 34H CONVERGENCE FAILURE-LOCAL MINIMUM )
      GO TO 265
  205 IF(QQ(1).LT.PQ(4,1)) GO TO 210
      IF(QQ(2).LT.PQ(4,1)) GO TO 220
      PQ(3,1)=QQ(1)
      PQ(5,1)=QQ(2)
      SQ(3)=SQ(1)
      SQ(5)=SQ(2)
      GO TO 170
  210 PQ(5,1)=PQ(4,1)
      PQ(4,1)=QQ(1)
      SQ(5)=SQ(4)
      SQ(4)=SQ(1)
      GO TO 170
  220 PQ(3,1)=PQ(4,1)
```

```
      PQ(4,1)=QQ(2)
      SQ(3)=SQ(4)
      SQ(4)=SQ(2)
      GO TO 170
  230 DO 245 M=3,5
      DO 240 L=J1,J2
  240 PQ(M,1)=PQ(M,1)*(SQ(M)-SOMNAT(L,I))/(SMEAN-SOMNAT(L,I))
  245 PQ(M,1)=SIGN(PQ(M,1),PF)
      L1=2+K
      L2=3+K
      L3=0
      CALL ITER(I,SQ(L1),SQ(K),PQ(L1,1),PQ(K,1))
  250 IF(.NOT.OVRG) GO TO 260
      KNT=KNT+1
      TOMNAT(KNT)=SOM
  260 CONTINUE
      IF(L3.NE.0)  GO TO 265
      CALL ITER(I,SQ(K),SQ(L2),PQ(K,1),PQ(L2,1))
      L3=1
      GO TO 250
  265 CONTINUE
  270 IF(KNT.EQ.0) GO TO 310
      J1=IN(I)+KNT
      IN(I)=J1
      J3=KNT
      DO 300 J=1,KNT
  280 IF(J2.LT.IBS(IST,IB,I).OR.TOMNAT(J3).GT.SOMNAT(J2,I))  GO TO 290
      SOMNAT(J1,I)=SOMNAT(J2,I)
      J2=J2-1
      J1=J1-1
      GO TO 280
  290 SOMNAT(J1,I)=TOMNAT(J3)
      J3=J3-1
  300 J1=J1-1
  310 CONTINUE
C
  320 IBE(IST,IB,1)=IN(I)
C
      DET =.FALSE.
      MSZ =MM4
C
  710 CALL AMPLTD
C
      ISTE(IST,3)=IN(3)
      ISTE(IST,1)=IN(1)
  700 ISTE(IST,2)=IN(2)
C****************************************
C CALCULATE AND PRINT OUT MODE SHAPES *
C****************************************
      CALL SUMMY
C**********************************
C PLOT NATURAL FREQ. VS ROTOR RPM *
C**********************************
      IF( LOT)  CALL PLOUT
      GO TO 10
 1000 STOP
      END
```

OS/360 FORTRAN H

```
OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
          SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      BLOCK DATA
C
      COMMON /COMA/ JHUB, N1,       LOT,POUT,ITLF(19),NAME(2),ND(2),NPG
     *,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41),INPUN
      COMMON /COMC/ N,IER(7),OFFSET
      COMMON /COME/ ZB(205), ZX(205), ZQ(205), ZL(205), ZS(205), ZY(205)
     *,ZM(205), ZD(205), ZH(205), ZT(205)
      COMMON /COMTP/ DEG(200,3),PLNE(2,4),ODES(2,5)
      LOGICAL IER,OFFSET
C        REAL *8 SPECIFICATION FOR IBM: COMMENTED FOR CDC VERSION.
      REAL*8 PLNE,ODES
      REAL*8 ZB,ZS,ZX,ZY,ZH,ZM,ZQ,ZL,ZD,ZT
      REAL*8         BEBE      ,BEPS      ,BEX       ,BEPH      ,BEY
     *               , XBE     , XPS      , XX       , XPH      , XY
     *               , QBE     , QPS      , QX       , QPH      , QY
     *               ,ELBE     ,ELPS      ,ELX       ,ELPH      ,ELY
     *               ,PSBE     ,PSPS      ,PSX       ,PSPH      ,PSY
     *               , YBE     , YPS      , YX       , YPH      , YY
     *               ,BMBE     ,BMPS      ,BMX       ,BMPH      ,BMY
     *               ,DEBE     ,DEPS      ,DEX       ,DEPH      ,DEY
     *               ,PHBE     ,PHPS      ,PHX       ,PHPH      ,PHY
     *               , TBE     , TPS      , TX       , TPH      , TY
      DIMENSION            BEBE(41) ,BEPS(41) ,BEY(41)  ,BEPH(41) ,BEX(41)
     *                    ,PSBE(41) ,PSPS(41) ,PSY(41)  ,PSPH(41) ,PSX(41)
     *                    ,YBE(41)  ,YPS(41)  ,YY(41)   ,YX(41)   ,YPH(41)
     *                    ,XBE(41)  ,XPS(41)  ,XY(41)   ,XX(41)   ,XPH(41)
     *                    ,PHBE(41) ,PHPS(41) ,PHY(41)  ,PHPH(41) ,PHX(41)
     *                    ,BMBE(41) ,BMPS(41) ,BMY(41)  ,BMPH(41) ,BMX(41)
     *                    ,QBE(41)  ,QPS(41)  ,QY(41)   ,QX(41)   ,QPH(41)
     *                    ,ELBE(41) ,ELPS(41) ,ELY(41)  ,ELPH(41) ,ELX(41)
     *                    ,DEBE(41) ,DEPS(41) ,DEY(41)  ,DEPH(41) ,DEX(41)
     *                    ,TBE(41)  ,TPS(41)  ,TY(41)   ,TX(41)   ,TPH(41)
      EQUIVALENCE  (ZB(1),BEBE(1)),(ZB(42),BEPS(1)),(ZB(83),BEX(1)),
     1             (ZB(124),BEPH(1)),(ZB(165),BEY(1)),
     2             (ZX(1),XBE(1) ),(ZX(42), XPS(1)),(ZX(83),XX(1)),
     3             (ZX(124), XPH(1)),(ZX(165), XY(1)),
     4             (ZQ(1), QBE(1)),(ZQ(42), QPS(1)),(ZQ(83), QX(1)),
     5             (ZQ(124), QPH(1)),(ZQ(165), QY(1)),
     6             (ZL(1),ELBE(1)),(ZL(42),ELPS(1)),(ZL(83),ELX(1)),
     7          (ZL(124),ELPH(1)),(ZL(165),ELY(1)),
     8             (ZS(1),PSBE(1)),(ZS(42),PSPS(1)),(ZS(83),PSX(1)),
     9             (ZS(124),PSPH(1)),(ZS(165),PSY(1))
      EQUIVALENCE  (ZY(1), YBE(1)),(ZY(42), YPS(1)),(ZY(83), YX(1)),
     1             (ZY(124), YPH(1)),(ZY(165), YY(1)),
     2             (ZM(1),BMBE(1)),(ZM(42),BMPS(1)),(ZM(83),BMX(1)),
     3             (ZM(124),BMPH(1)),(ZM(165),BMY(1)),
     4             (ZD(1),DEBE(1)),(ZD(42),DEPS(1)),(ZD(83),DEX(1)),
     5             (ZD(124),DEPH(1)),(ZD(165),DEY(1)),
     6             (ZH(1),PHBE(1)),(ZH(42),PHPS(1)),(ZH(83),PHX(1)),
     7             (ZH(124),PHPH(1)),(ZH(165),PHY(1)),
     8             (ZT(1),TBE(1)),(ZT(42),  TPS(1)),(ZT(83), TX(1)),
     9             (ZT(124), TPH(1)),(ZT(165), TY(1))
      DATA CDATE/4H02/2,4H5/75/
      DATA OFFSET /.FALSE./
      DATA IER/7*.FALSE./
      DATA BEBE(1), BEPS(1), BEY(1), BEPH(1), BEX(1),
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*      PSBE(1), PSPS(1), PSY(1), PSPH(1), PSX(1),                       BLKD0570
*       YBE(1),  YPS(1),  YY(1),  YPH(1),  YX(1),                       BLKD0580
*       XBE(1),  XPS(1),  XY(1),  XPH(1),  XX(1),                       BLKD0590
*      PHBE(1), PHPS(1), PHY(1), PHPH(1), PHX(1),                       BLKD0600
*      BMBE(1), BMPS(1), BMY(1), BMPH(1), BMX(1),                       BLKD0610
*       QBE(1),  QPS(1),  QY(1),  QPH(1),  QX(1),                       BLKD0620
*      ELBE(1), ELPS(1), ELY(1), ELPH(1), ELX(1),                       BLKD0630
*      DEBE(1), DEPS(1), DEY(1), DEPH(1), DEX(1),                       BLKD0640
*       TBE(1),  TPS(1),  TY(1),  TPH(1),  TX(1)                        BLKD0650
*    /   1.D0,    0.D0,    0.D0,    0.D0,    0.D0,                      BLKD0660
*        0.D0,    1.D0,    0.D0,    0.D0,    0.D0,                      BLKD0670
*        0.D0,    0.D0,    1.D0,    0.D0,    0.D0,                      BLKD0680
*        0.D0,    0.D0,    0.D0,    0.D0,    1.D0,                      BLKD0690
*        0.D0,    0.D0,    0.D0,    1.D0,    0.D0, 25*0.D0/             BLKD0700
 DATA PLNE/8HVERT PLA,8HNE     ,8HHORIZ PL,8HANE     ,8H TORSION, BLKD0710
1        3*8H       /,  ODES /8HRIGID BO,8HDY     ,8H   1 NOD,  BLKD0720
2          8HE      ,8H   2 NOD,8HES     ,8H3 OR MOR,8HE NODES , BLKD0730
3        2*8H       /                                             BLKD0740
 END                                                              BLKD0750
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OS/360 FORTRAN H

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    OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
              SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE AMPLTD                                                 AMPL0010
C*****************************************************************     AMPL0020
C THIS SUBROUTINE CALCULATES AND PRINTS OUT MODE SHAPES *              AMPL0030
C*****************************************************************     AMPL0040
      COMMON /COMA/ JHUB, N1,      LOT,POUT,ITLE(19),NAME(2),ND(2),NPG  AMPL0050
     *,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41),INPUN                    AMPL0060
      COMMON /COMB/ CK, IRCOL, XRCOL(10), IBOM, RBOM(10) ,              AMPL0070
     * SMZ(41), ZBAR(40), EYEB(120),                                    AMPL0080
     * EYEC(120),SB(40), SC(40), VMB(40), VMC(40), VFB(40), VFC(40),    AMPL0090
     * DFB(40), DFC(40), TH(41), THE(40), WT(40), SM(42),ISOM,XOSOM(200)AMPL0100
     *,AZBAR,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC,CHORD                     AMPL0110
     *,RB(41),RC(41)                                                    AMPL0120
      COMMON /COMD/ CMAT(5,5),SOMNAT(200,3),IPLN(200,3),INODE(200,3),   AMPL0130
     1  MM3,MM4,MM5,CT(41), ST(41), IR ,IST,                            AMPL0140
     2   IBS(10,10,3),IBE(10,10,3),ISTS(10,3),ISTE(10,3)                AMPL0150
      COMMON /COME/ ZB(205), ZX(205), ZQ(205), ZL(205), ZS(205), ZY(205)AMPL0160
     *,ZM(205), ZD(205), ZH(205), ZT(205)                               AMPL0170
      COMMON /HINGES/ LCH,LCHP1,LFH,LFHP1 ,CHOFF,FHOFF,FCH,FFH,IPUNCT   AMPL0180
     * ,RPMPUN,COLPUN                                                   AMPL0190
     *,LPH,LPHP1,PHOFF,FPH                                              AMPL0200
     *,BOMM,TWSM ,LDYN5                                                 AMPL0210
     *,LOTS                                                             AMPL0220
     *,BOMI,TWSI,DELBOM,DELTWS                                          AMPL0230
      COMMON /COMI/ DET,MSZ, IGOOFD , SOM, OVRG                         AMPL0240
      COMMON /COMT/ EYX(41), EYB(41), EYC(41), YB(41), YC(41), XIMI(41),AMPL0250
     * XIT(41), EYR(41), FMRB(41), FMRC(41), EMRR(41), EMRSO(41), CCO2  AMPL0260
     *,OVPLT,OVLIN,SVLIN                                                AMPL0270
     *,      BLADES,HUBTYP                                              AMPL0280
      COMMON /COMTP/ DEG(200,3),PLNE(2,4),ODES(2,5)                     AMPL0290
      LOGICAL DET                                                       AMPL0300
      LOGICAL CONV, AM1, AM2, POUT, CCO2                                AMPL0310
     *,RBTEST                                                           AMPL0320
     *,LOTS                                                             AMPL0330
     *,LDYN5                                                            AMPL0340
     6,OVPLT,OVLIN,SVLIN                                                AMPL0350
C       REAL *8 SPECIFICATION FOR IBM: COMMENTED FOR CDC VERSION.       AMPL0360
      REAL*8 CMAT,DMAT,VEC,DVEC,DA,A,DUM                                AMPL0370
     *, PLNE, ODES                                                      AMPL0380
      REAL*8 ZB,ZS,ZX,ZY,ZH,ZM,ZQ,ZL,ZD,ZT                              AMPL0390
      REAL*8         BEBE      ,BEPS      ,BEX       ,BEPH      ,BEY    AMPL0400
     *               , XBE     , XPS      , XX       , XPH      , XY    AMPL0410
     *               , OBE     , OPS      , OX       , OPH      , OY    AMPL0420
     *               ,ELBE     ,ELPS      ,ELX       ,ELPH      ,ELY    AMPL0430
     *               ,PSBE     ,PSPS      ,PSX       ,PSPH      ,PSY    AMPL0440
     *               , YBE     , YPS      , YX       , YPH      , YY    AMPL0450
     *               ,BMBE     ,BMPS      ,BMX       ,BMPH      ,BMY    AMPL0460
     *               ,DEBE     ,DEPS      ,DEX       ,DEPH      ,DEY    AMPL0470
     *               ,PHBE     ,PHPS      ,PHX       ,PHPH      ,PHY    AMPL0480
     *               , TBE     , TPS      , TX       , TPH      , TY    AMPL0490
      DIMENSION         BEBE(41) ,BEPS(41) ,BEY(41)  ,BEPH(41) ,BEX(41)AMPL0500
     *                 ,PSBE(41) ,PSPS(41) ,PSY(41)  ,PSPH(41) ,PSX(41)AMPL0510
     *                 ,YBE(41)  ,YPS(41)  ,YY(41)   ,YX(41)   ,YPH(41)AMPL0520
     *                 ,XBE(41)  ,XPS(41)  ,XY(41)   ,XX(41)   ,XPH(41)AMPL0530
     *                 ,PHBE(41) ,PHPS(41) ,PHY(41)  ,PHPH(41) ,PHX(41)AMPL0540
     *                 ,BMBE(41) ,BMPS(41) ,BMY(41)  ,BMPH(41) ,BMX(41)AMPL0550
     *                 ,OBE(41)  ,OPS(41)  ,OY(41)   ,OX(41)   ,OPH(41)AMPL0560
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     *               ,ELBE(41) ,ELPS(41) ,ELY(41)  ,ELPH(41) ,ELX(41)
     *               ,DEBE(41) ,DEPS(41) ,DEY(41)  ,DEPH(41) ,DEX(41)
     *               ,TBE(41)  ,TPS(41)  ,TY(41)   ,TX(41)   ,TPH(41)
      DIMENSION    U-AT(5,5), VEC(5), DVEC(5),     A(5), DUM(41,5,20)
      DIMENSION    B(3,41),DUMY(1,1),S(1)
     1,BBM(41),CBM(41),TOR(41)
      EQUIVALENCE (DUM(1),BEBE(1))
      EQUIVALENCE (ZB(1),BEBE(1)),(ZB(42),BEPS(1)),(ZB(83),BEX(1)),
     1            (ZB(124),BEPH(1)),(ZB(165),BEY(1)),
     2            (ZX(1),XBE(1) ),(ZX(42), XPS(1)),(ZX(83),XX(1)),
     3            (ZX(124), XPH(1)),(ZX(165), XY(1)),
     4            (ZO(1), QBE(1)),(ZQ(42), QPS(1)),(ZQ(83), QX(1)),
     5            (ZO(124), QPH(1)),(ZQ(165), QY(1)),
     6            (ZL(1),ELBE(1)),(ZL(42),ELPS(1)),(ZL(83),ELX(1)),
     7           (ZL(124),ELPH(1)),(ZL(165),ELY(1)),
     8            (ZS(1),PSBE(1)),(ZS(42),PSPS(1)),(ZS(83),PSX(1)),
     9            (ZS(124),PSPH(1)),(ZS(165),PSY(1))
      EQUIVALENCE (ZY(1), YBE(1)),(ZY(42), YPS(1)),(ZY(83), YX(1)),
     1            (ZY(124), YPH(1)),(ZY(165), YY(1)),
     2            (ZM(1),BMBE(1)),(ZM(42),BMPS(1)),(ZM(83),BMX(1)),
     3            (ZM(124),BMPH(1)),(ZM(165),BMY(1)),
     4            (ZD(1),DEBE(1)),(ZD(42),DEPS(1)),(ZD(83),DEX(1)),
     5            (ZD(124),DEPH(1)),(ZD(165),DEY(1)),
     6            (ZH(1),PHBE(1)),(ZH(42),PHPS(1)),(ZH(83),PHX(1)),
     7            (ZH(124),PHPH(1)),(ZH(165),PHY(1)),
     *            (ZT(1),TBE(1)),(ZT(42),  TPS(1)),(ZT(83), TX(1)),
                  (ZT(124), TPH(1)),(ZT(165), TY(1))
      DATA CVCPM/9.5492966/, CVDT/5.729578/
C**********************************
C MODE LOOP  M=1 FOR COLLECTIVE MODE *
C            M=2 FOR CYCLIC MODES    *
C            M=3 FOR SCISSORS MODES  *
C**********************************
      T=0.0
      NCOLM=0
      NCYCM=0
      DO 227 M=1,3
C  BYPASS COLLECTIVE AND CYCLIC MODES FOR ARTICULATED ROTOR.
      IF(M.NE.3.AND.HOFF.NE.0) GO TO 227
      IF(M.NE.3.AND.CHOFF.NE.0) GO TO 227
      MODENO=0
      IF(IBE(IST,IB,M) .LE. IBS(IST,IB,M) )GO TO 227
C*******************************************
C SWEEP NATURAL FREQUENCIES STORED IN SOMNAT *
C*******************************************
      NPT = 1+ IBE(IST,IB,M) -IBS(IST,IB,M)
      DO 223 NP=1,NPT
      NPS = NP +IBS(IST,IB,M) -1
      S(1)=SOMNAT(NPS,M)
      CALL COEF(M,M,.TRUE.,1,S    ,     DUMY)
      FNAT = CVCPM *SQRT(S(1))
      SOMNAT(NPS,M) = FNAT
      DET=.TRUE.
C******************************
C  S      DMAT  =VEC    FOR A
C   THE   BETA(TIP)=A(1)*Z(TIP) *
C         Y(TIP)    =A(3)*Z(TIP) *
C         PSI(TIP)  =A(2)*Z(TIP) *
```

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C           PHI(TIP) =A(4)*Z(TIP) *
C*********************************************
      DO 250 I=1,MM5
      A(I)=0.D0
      DO 240 J=1,MM5
      DMAT(I,J)=CMAT(I,J)
  240 A(I)= DMAX1(A(I),DABS(DMAT(I,J)))
  250 A(I)=1.D0/A(I)
      DO 255 I=1,MM5
      DO 255 J=1,MM5
  255 DMAT(I,J)=DMAT(I,J)*A(I)
      P2=0.
      DO 280 I=1,MM5
      IRW=0
      DO 270 J=1,MM5
      IF(J.EQ.I)  GO TO 270
      IRW=IRW+1
      DO 260 K=1,MM4
  260 CMAT(IRW,K)=DMAT(J,K)
  270 CONTINUE
      CALL INVDET(P1)
      IF(ABS(P1).LT.P2)  GO TO 280
      JRW=I
      P2=ABS(P1)
  280 CONTINUE
      IRW=0
      DO 300 I=1,MM5
      A(I)=0.D0
      IF(I.EQ.JRW)  GO TO 300
      IRW=IRW+1
      VEC(IRW)=-DMAT(I,MM5)
      DVEC(IRW)=VEC(IRW)
      DO 290 J=1,MM4
      CMAT(IRW,J)=DMAT(I,J)
  290 DMAT(IRW,J)=DMAT(I,J)
  300 CONTINUE
      DET=.FALSE.
      CALL INVDET(DUMYY)
      KLM=0
   50 CONV=.TRUE.
      DO 70 I=1,MM4
      DA=0.D0
      DO 60 J=1,MM4
   60 DA=DA+CMAT(I,J)*DVEC(J)
      IF(DA.EQ.0.D0) GO TO 70
      A(I)=A(I)+DA
      CONV=CONV.AND.DA/A(I).LE..000001
   70 CONTINUE
      IF(CONV) GO TO 100
      KLM=KLM+1
      IF(KLM.GT.25) GO TO 90
      DO 80 I=1,MM4
      DVEC(I)=VEC(I)
      DO 80 J=1,MM4
   80 DVEC(I) DVEC(I)-DMAT(I,J)*A(J)
      GO TO 50
   90 WRITE(6,907)    FNAT    , DBOM(IB)
  907 FORMAT (24H CONVERGENCE FAILURE AT ,F9.2,18H CPM, ROTOR RPM = ,
```

```
     * F9.2)
      INODE(NPS,M) = 5
      IPLN(NPS,M) = 4
      DEG(NPS,M) = 180.
      GO TO 223
C**************************
C CALCULATE MODE SHAPES *
C**************************
 100  IF(CCO2) A(4)=0.D0
      L=N1+1
      DO 115 I=1,N1
      L=L-1
      B(1,L)=YBE(I)*A(1)+YPS(I)*A(2)+YY(I)+YX(I)*A(3)+YPH(I)*A(4)
      B(2,L)=XBE(I)*A(1)+XPS(I)*A(2)+XY(I)+XX(I)*A(3)+XPH(I)*A(4)
       IF(CCO2) B(3,L)=0.0
      IF( M.EQ.3.AND.FHOFF.NE.0.0.AND.I.GE.(N1-LFH))B(1,L)=0.0
      IF( M.EQ.3.AND.CHOFF.NE.0.0.AND.I.GE.(N1-LCH))B(2,L)=0.0
 110  IF( .NOT.CCO2)B(3,L)=(PHBE(I)*A(1)+PHPS(I)*A(2)+PHY(I)+PHX(I)*A(3)
     * +PHPH(I)*A(4))*CVDT
  115 IF(PHOFF.NE.0.0.AND.I.GE.(N1-LPH))B(3,L)=B(3,L+1)
      ABSCL=0.
      DO 120 I=1,MM3
      DO 120 J=1,N1
      ABSB=ABS(B(I,J))
      IF(ABSCL.GT.ABSB) GO TO 120
      IPLN(NPS,M) = I
      SCALE=B(I,J)
      ABSCL=ABSB
 120  CONTINUE
      SCALE=1./SCALE
      ABSB=SCALE
      DO 150 I=1,MM3
      IF(I.EQ.3) ABSB=10.*ABSB
      DO 150 J=1,N1
 150  B(I,J)=B(I,J)*ABSB
      IF( .NOT. POUT) GO TO 10
      IF(RCOLL(IST) .NE. COLPUN .OR. DBOM(IB) .NE. RPMPUN) GO TO 10
C     BYPASS MODE PLOTS IF THESE MODES ARE NOT TO BE PRINTED.
      CALL MDPLOT(B,NP,M,NPT,  FNAT    ,DBOM(IB) )
   10 CONTINUE
      NNODE = 2
      K=IPLN(NPS,M)
      AM2=B(K,3).GT.B(K,2)
      DO 160 I=4,N1
      AM1=B(K,I).GT.B(K,I-1)
      IF(.NOT.(AM1 .AND.AM2).AND.(AM1.OR.AM2))  NNODE    =NNODE    +1
      IF(NNODE     .LE.4)  GO TO 180
 160  AM2=AM1
      IF(NNODE     .NE.2.OR.K.EQ.3.OR.K.EQ.        M) GO TO 180
      L=7
      IF(K.EQ.2) L=3
      DO 170 I=1,N1
      IF(SCALE*(DUM(I,1,L)*A(1)+DUM(I,2,L)*A(2)+DUM(I,3,L)*A(3)+
       DUM(I,4,L)*A(4)+DUM(I,5,L)).GT.1.E4) GO TO 180
 170  CONTINUE
      NNODE     =1
 180  ABSCL=0.
      DO 310 I=1,N1
```

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      ABSB=SQRT(B(1,I)**2+B(2,I)**2)
      IF(ABSCL.GT.ABSB)  GO TO 310
      ABSCL=ABSB
      J=I
  310 CONTINUE
      DEG(NPS,M)=-57.29578*ATAN2(B(1,J),B(2,J))
      INODE(NPS,M) = NNODE
      IF(.NOT.POUT.AND.INPUN.NE.1) GO TO 223
      IF(.NOT.LDYN5) GO TO 190
      IF(LOTS) GO TO 190
      IF(SVLIN.AND.OVPLT.AND.OVLIN) GO TO 223
      IF(RCOLL(IST).NE.COLPUN.OR.DBOM(IB).NE.RPMPUN) GO TO 225
  190 CONTINUE
      NPG=NPG+1
      WRITE(6,901) NPG, CDATE, ND, NAME, ITLE
  901 FORMAT (1H1,27X,4HPAGE ,I3,12X, 29HBHC PROGRAM DF1758 -COMPILED ,
     1 2A4,11X,2A4 /28X,A4,A2,24X, 19HNATURAL BLADE MODES //48X,9A4,A1 /
     2 49X ,8A4,A3 )
      IF(         M.EQ.1) WRITE(6,902)     FNAT
  902 FORMAT (46X,27HCOLLECTIVE MODE OF BLADE AT ,F9.2,4H CPM )
      IF(         M.EQ.2) WRITE(6,903) FNAT
  903 FORMAT (48X,23HCYCLIC MODE OF BLADE AT ,F9.2,4H CPM )
      IF(M.EQ.3)  WRITE(6,916)   FNAT
  916 FORMAT (47X, 5HSCISSORS MODE OF BLADE AT , F9.2,4H CPM )
      FREQPP=0.
      IF(DBOM(IB).NE.0.) FREQPR=  FNAT     /DBOM(IB)
      WRITE(6,920)  FREQPR
  920 FORMAT (50X,24H NATURAL FREQUENCY IS:  ,F9.4,4X,8HPER REV  )
      WRITE(6,909) RCOLL(IST),DBOM(IB), PLNE(1,K ), PLNE(2,K ),
     *ODES(1,NNODE     ), ODES(2,NNODE     ), DEG(NPS,M)
  908 FORMAT (46X,F11.2,23H DEGREE ROOT COLLECTIVE /46X,F10.2,
     1  10H ROTOR RPM /41X,21HMAXIMUM AMPLITUDE IN ,A8,A3,3H - ,2A8 /
     2  49X,23HMAX DEFLECTION PLANE AT ,F6.1,4H DEG )
      WRITE(6,909)
  909 FORMAT (10X,9HBLADE STA,8X,11HDEFLECTIONS ,19X,7HMOMENTS ,20X,
     1  12HSHEAR FORCES ,12X,5HTWIST ,6X,6HTORQUE /13X,2HIN,15X,5HIN(1),
     2  22X,8HIN-LB(1),22X,5HLB(1),16X,6HDEG(1),4X,8HIN-LB(1) /26X,
     3  4HVERT,4X,5HHORIZ,13X,4HBEAM,8X,5HCHORD,13X,4HBEAM,6X,5HCHORD /
     4  2X,16(8H******** ) /)
      L=N1+1
      WRITE(6,910)
  910  ORMAT (63X, 7H**HUB** )
      ASSIGN 200 TO MBR1
      DO 210 J=1,JHUB1
      IF(CCO2) B(3,J)=0.0
      L=L-1
      GO TO 230
  200 WRITE(6,911) J, Z(J), B(1,J), B(2,J), BM, Q, FL, DF
  911 FORMAT(6X,I3,F8.2,F14.3,F8.3,F19.0,F12.0,F16.0,F11.0)
  210 IF(.NOT.CCO2) WRITE(6,912) B(3,J), T
  912 FORMAT(1H+,97X,F15.3,F13.0)
      WRITE(6,913)
  913 FORMAT (1H0, 61X ,11H** BLADE ** )
      ASSIGN 220 TO MBR1
      DO 220 J=JHUB1,N1
      IF(CCO2) B(3,J)=0.0
      QBM=BM*CT(J)+Q*ST(J)
      QCO=Q*CT(J)-BM*ST(J)
```

```
      FBM=EL*CT(J)+DE*ST(J)
      FCD=DE*CT(J)-EL*ST(J)
      WRITE(6,911) J, Z(J), B(1,J), B(2,J), QBM, QCD, FBM, FCD
      IF(.NOT.CCO2) WRITE(6,912) P(3,J), T
      L=L-1
      IF(J.NE.N1) GO TO 230
  220 CONTINUE
      IF (K.LT.3) WRITE (6,914)
      IF (K.EQ. 3) WRITE (6,915)
  914 FORMAT (1H0,49X,34HNOTE    (1) PER INCH MAX DEFLECTION )
  915 FORMAT (1H0,51X,31HNOTE    (1) PER 10 DEG MAX TWIST )
      GINT=0.0
      DO 410 N=1,21
      GINT=GINT+SM(N)*(B(1,N)**2+B(2,N)**2)+EVR(N)*(B(3,N)/57.3)**2
      IF(.NOT.LDYN5) GO TO 410
      IF(ABS(B(3,N)) .LE. 0.01) B(3,N)=0.0
  410 CONTINUE
  412 CONTINUE
      WRITE (6,407) GINT
  407 FORMAT (//29H   THE GENERALIZED INERTIA IS ,F10.5,
     1  16H IN-LBF-SEC**2    )
  225 CONTINUE
      CALL CARDS(M,MODENO,NPS,    ICOL,IRPM,   P )
 223  CONTINUE
 227  CONTINUE
      RETURN
 230  BM=(BMBE(L)*A(1)+BMPS(L)*A(2)+BMY(L)+BMX(L)*A(3)+BMPH(L)*A(4))
     * *SCALE
      Q=(QBE(L)*A(1)+QPS(L)*A(2)+QY(L)+QX(L)*A(3)+QPH(L)*A(4))*SCALE
      EL=(ELBE(L)*A(1)+ELPS(L)*A(2)+ELY(L)+ELX(L)*A(3)+ELPH(L)*A(4))
     * *SCALE
      DE=(DEBE(L)*A(1)+DEPS(L)*A(2)+DEY(L)+DEX(L)*A(3)+DEPH(L)*A(4))
     * *SCALE
      IF(.NOT.CCO2) T=(TBE(L)*A(1)+TPS(L)*A(2)+TY(L)+TX(L)*A(3)+TPH(L)
     * *A(4))*SCALE
      IF(PHOFF .NE .0..AND. J .LE. LPH) T = 0.0
      GO TO MBR1, (200,220)
      END
```

OS/360 FORTRAN H

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    OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
              SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE CARDS(M,MODENO,NPS,    ICOL,IRPM,   B )
C*************************************************************
C THIS SUBROUTINE  PUNCHES OUT MODE SHAPES    *
C*************************************************************
      COMMON /COMA/ JHUB, NI,       LOT,POUT,ITLE(19),NAME(2),ND(2),NPG
     *,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41),INPUN
      COMMON /COMD/ CMAT(5,5),SOMNAT(200,3),IPLN(200,3),INODE(200,3),
     1  MM3,MM4,MM5,CT(41), ST(41), IB ,IST,
     2   IBS(10,10,3),IBE(10,10,3),ISTS(10,3),ISTE(10,3)
      COMMON /HINGES/ LCH,LCHP1,LFH,LFHP1 ,CHOFF,FHOFF,FCH,FFH,IPUNCT
     * ,RPMPUN,COLPUN
     *,LPH,LPHP1,PHOFF,FPH
     *,BOMM,TWSM ,LDYN5
     *,LOTS
     *,BOMI,TWSI,DELBOM,DELTWS
      COMMON /COMT/ EYX(41), EYB(41), EYC(41), YB(41), YC(41), XIMI(41),
     * XIT(41), EYR(41), EMRB(41), EMRC(41), EMRR(41), EMPSO(41), CCO2
     *,OVPLT,OVLIN,SVLIN
     *,       BLADES,HUBTYP
      LOGICAL DET
      LOGICAL CONV, AM1, AM2, POUT, CCO2
     *,RBTEST
     *,LOTS
     *,LDYN5
     6,OVPLT,OVLIN,SVLIN
C        REAL *8 SPECIFICATION FOR IBM; COMMENTED FOR CDC VERSION.
      REAL*8 CMAT
      DIMENSION B(3,41)
     2 ,PUN(22,3)
     3,D(6,3,6)
      DIMENSION YEN(10,3,3,3,4,3),YENFRQ(3,3,4,3)
C***************************************
C MODE LOOP  M=1 FOR COLLECTIVE MODE *
C            M=2 FOR CYCLIC MODES    *
C            M=3 FOR SCISSORS MODES  *
C***************************************
      MODENO=MODENO+1
      IF(RCOLL(IST).NE.COLPUN.OR.DBOM(IB).NE.RPMPUN) GO TO 702
C
C
      DO 25 KK=1,21
      K=KK
      PUN(KK,1)=B(1,K)
      PUN(KK,2)=B(2,K)
      PUN(KK,3)=B(3,K)* 12.
   25 CONTINUE
       DO 200 J=2,21
      RNEW=(J-1)*Z(21)/20.
      FRACT=0.0
      DO 205 I=2,21
      IF(RNEW.GT.Z(I-1).AND.RNEW.LE.Z(I))
     1FRACT=(RNEW-Z(I-1))/(Z(I)-Z(I-1))
      IF(FRACT.EQ.0.0) GO TO 205
      PUN(J,1)=B(1,I-1)+FRACT*(B(1,I)-B(1,I-1))
      PUN(J,2)=B(2,I-1)+FRACT*(B(2,I)-B(2,I-1))
      PUN(J,3)=(B(3,I-1)+FRACT*(B(3,I)-B(3,I-1)))*12.
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      IF(FRACT.NE.0.0) GO TO 209
  205 CONTINUE
  209 CONTINUE
  200 CONTINUE
      PUN(22,1)=SOMNAT(NPS,M)/DBOM(IB)
      IF(M.EQ. 1)PUN(22,2)= 1.
      IF(M.EQ. 2)PUN(22,2)=-1.
      IF(M.EQ. 3)PUN(22,2)=0.
      PUN(22,3)=.02
      ANGLLH=0.0
      IF(Z(41).EQ.0.0) GO TO 208
      IHNG=Z(41)
      ANGLLH=12.*57.3*(B(2,IHNG+2)-B(2,IHNG+1))/(Z(IHNG+2)-Z(IHNG+1) )
     1  -(B(2,IHNG)-B(2,IHNG-1))/(Z(IHNG)-Z(IHNG-1))
      WRITE(6,73)ANGLLH
   73 FORMAT(73H THE LEAD-LAG ANGLE FOR THIS MODE ,SCALED TO 1 FOOT MAX
     1 DISPLACEMENT,IS,F10.5,10H   DEGREES)
  208 CONTINUE
      IF(INPUN.NE.1) GO TO 7
      IF(MODENO.GT.6) GO TO 7
      RBTEST=.FALSE.
      IF(ABS(PUN(22,1)-1.).LE..05) RBTEST=.TRUE.
      DO 450 KN=1,21
      IF(M.EQ.2.AND.RBTEST) PUN(KN,3)=0.0
  450 CONTINUE
      IF(M.EQ.2.AND.RBTEST) PUN(22,3)=0.0
       IF(RCOLL(IST).EQ.1.) GO TO 7
      IDBOM=DBOM(IB)
      ISW=PUN(22,2)
      DO  600  KKK=1,21,2
      IF(RCOLL(IST).NE.COLPUN.OR.DBOM(IB).NE.RPMPUN) GO TO 600
      KKKP1=KKK+1
      WRITE(7,27)  (PUN(KKK,I),I=1,3), PUN(KKKP1 ,I),I=1,3),NAME,
     1MODENO,ISW,RCOLL(IST),IDBOM
  600 CONTINUE
      WRITE(7,300)ANGLLH,NAME,MODENO,ISW,RCOLL(IST),IDBOM
  300 FORMAT(F10.6,50X,A4,A2,I2,I3,F4.0,I5)
  702 CONTINUE
      IF(MODENO.GT.6) RETURN
C   SORT CYCLIC DETUNING DATA FOR C81
      IF(IB.EQ.1.AND.IST.EQ.1)D(1,M,MODENO)=SOMNAT(NPS,M)
      IF(IB.EQ.1.AND.IST.EQ.3)D(2,M,MODENO)=SOMNAT(NPS,M)
      IF(IB.EQ.3.AND.IST.EQ.1)D(3,M,MODENO)=SOMNAT(NPS,M)
      IF(IB.EQ.3.AND.IST.EQ.3)D(4,M,MODENO)=SOMNAT(NPS,M)
C
   27 FORMAT(6F10.6,A4,A2,I2,I3,F4.0,I5)
    7 CONTINUE
C    FOLLOWING 36 CARDS ARE COMMENTED TO SAVE CORE SPACE.
C   IF MODES TO FIT BHC PROGRAM DYN5 ARE DESIRED, REMOVE C'S HERE
C   AND ON DIMENSION STATEMENT FOR YEN AND YENFRQ.
      IF(LDYN5) GO TO 460
      IF (MODENO .GT. 4) GO TO 469
      DO 437 ISEG=1,10
      DO 437 ICOMP=1,3
      IF(ICOMP.EQ.3)B(3,ISEG*2+1)=B(3,ISEG*2+1)/57.3
      YEN(ISEG,IST,IB,ICOMP,MODENO,M)=B(ICOMP,ISEG*2+1)
  437 CONTINUE
      YENFRQ(IST,IB,MODENO,M)=SOMNAT(NPS,M) *6.28/60.
```

```
  469 IF(M .NE. 3) GO TO 460
      IF(RCOLL(IST).NE.COLPUN) GO TO 460
      IF(DBOM(IB).NE.RPMPUN) GO TO 460
      IF (NPS .NE. IBE(IST,IB,M))GO TO 460
      DO 459 ITYPE=1,3
       DO 459 IMODEN=1,4
      WRITE(7,465)NAME
      WRITE (6,465) NAME
  465 FORMAT(30X,A4,A2)
      WRITE(7,464)((YENFRQ(ICOL,IRPM,IMODEN,ITYPE),ICOL=1,3),IRPM=1,3)
      WRITE (6,467)((YENFRQ(ICOL,IRPM,IMODEN,ITYPE),ICOL=1,3),IRPM=1,3)
  467 FORMAT (' ' 13F6.0)
      IYEN=ITYPE-1
      WRITE(7,466)IYEN
      WRITE (6,466) IYEN
  466 FORMAT (15H     1      1      1 ,I5 )
      DO 459 ICOMP=1,3
      WRITE(7,463)(((YEN(ISEG,ICOL,IRPM,ICOMP,IMODEN,ITYPE)
     1 ,ISEG=1,10),ICOL=1,3),IRPM=1,3)
      WRITE(6,468)(((YEN(ISEG,ICOL,IRPM,ICOMP,IMODEN,ITYPE),
     *  ISEG=1,10),ICOL=1,3),IRPM=1,3)
  468 FORMAT (' ' 13F6.3)
  459 CONTINUE
  460 CONTINUE
  464 FORMAT(     13F6.0)
  463 FORMAT(     13F6.3)
      IF(INPUN.NE.1) RETURN
C     PUNCH CYCLIC DETUNING CARDS FOR C81
  883 FORMAT(7I10)
      IDBOM=DBOM(2)
      ICOLL=RCOLL(2)
      DO 8 IM=1,3
      DO 8 IJ=1,6
      D(5,IM,IJ)=(RCOLL(3)-RCOLL(1))*.5
      D(6,IM,IJ)=(DBOM(3)-DBOM(1))*.5
      IF(IM.EQ.1) ISW=1
      IF(IM.EQ.2) ISW=-1
      IF(IM.EQ.3) ISW =0
      IF(IB.EQ.  AND.IST.EQ.3.AND.MODENO.EQ.6.AND.M.EQ.3)
     1WRITE(7,28)((D(I,IM,IJ),I=1,6),RCOLL(2),DBOM(2),NAME,IJ,ISW)
   28 FORMAT(6F10.0,2F5.0,A4,A2,2I2)
    8 CONTINUE
      RETURN
      END
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OS/360 FORTRAN H

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   OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE COEF(KIN, KAX, DET, IMAX, SQSOM, PP)
C*****************************************************************
C THIS SUBROUTINE CALCULATES THE DEFLECTION OF EACH STATION      *
C AS A FUNCTION OF DEFLECTIONS AT THE ROTOR BLADE TIP FOR        *
C                                                                *
C      MODES IA=KIN TO KAX  IA=1 FOR COLLECTIVE MODES            *
C                           IA=2 FOR CYCLIC MODES                *
C                           IA=3 FOR SCISSORS MODES              *
C                                                                *
C      IMAX=NO OF FREQUENCIES TO BE CALCULATED                   *
C      SQSOM(1 TO IMAX) CONTAINES SQUARES OF FREQUENCIES         *
C                                                                *
C      DET=.TRUE. USED TO FIND MODE SHAPE FOR KNOWN NATURAL FREQ. *
C                                                                *
C      DET=.FALSE. USED TO FIND NATURAL FREQ.-THE DETERMINATES OF *
C                   THE BOUNDRY CONDITION MATRICIES ARE CALCULATED *
C                   AND STORED IN PP(1 TO IMAX,KIN TO KAX).      *
C*****************************************************************
      COMMON /COMA/ JHUB, N1,      LOT,POUT,ITLE(19),NAME(2),ND(2),NPG
     *,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41),INPUN
      COMMON /COMB/ CK, IRCOL, XRCOL(10), IBOM, RBOM(10) ,
     * SMZ(41), ZBAR(40), EYEB(120),
     * EYEC(120),SB(40), SC(40), VMB(40), VMC(40), VFB(40), VFC(40),
     * DFB(40), DFC(40), TH(41), THE(40), WT(40), SM(42),ISOM,XQSOM(200)
     *,AZBAR,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC,CHORD
     *,RB(41),PC(41)
      COMMON /COMD/ CMAT(5,5),SOMNAT(200,3),IPLN(200,3),INODE(200,3),
     1  MM3,MM4,MM5,CT(41), ST(41), IB ,IST,
     2   IBS(10,10,3),IBE(10,10,3),ISTS(10,3),ISTF(10,3)
      COMMON/H/ VLX(40), VDX(40), VLY(40), VMX(40), VQX(40), VMY(40),
     *          DPLX(40),DPDX(40),DPLY(40),DPMX(40),DPQX(40),DPMY(40),
     *          DFLX(40),DFDX(40),DFLY(40),VFLX(40),VFDX(40),VFLY(40),
     * F(41), BOMS, DTX(41), DTY(41), SX(41), SY(41), EMRX(41),
     * EMRY(41), EMBBW(41), EMBBO(41), EMBPO(41), EMPPW(41), EMPPO(41),
     * THHC(41), FTX(41), FTY(41), WFL(41), WFD(41), EMBPW(41)
      COMMON /COMH/ SPRIP    ,FLPSPR
     *,VSOF ,VMAS ,HSOF ,HMAS ,RSOF
     1,SOFI
     *,TORSO
     1,ANGLE,STR
     1,ILOC,TANALF
      COMMON /HINGES/ LCH,LCHP1,LFH,LFHP1 ,CHOFF,FHOFF,FCH,FFH,IPUNCT
     * ,RPMPUN,COLPUN
     *,LPH,LPHP1,PHOFF,FPH
     *,BOMM,TWSM ,LDYN5
     *,LOTS
     *,BOMI,TWSI,DELBOM,DELTWS
      COMMON /COMT/ EYX(41), EYB(41), EYC(41), YB(41), YC(41), XIMI(41),
     * XIT(41), EYR(41), EMRB(41), EMRC(41), EMRR(41), EMRSQ(41), CC02
     *,OVPLT,OVLIN,SVLIN
     *,      BLADES,HUBTYP
      COMMON /COME/ ZB(205), ZX(205), ZQ(205), ZL(205), ZS(205), ZY(205)
     *,ZM(205), ZD(205), ZH(205), ZT(205)
      LOGICAL DET, CC02
C        REAL *8 SPECIFICATION FOR IBM; COMMENTED FOR CDC VERSION.
      REAL*8 ZB,ZS,ZX,ZY,ZH,ZM,ZQ,ZL,ZD,ZT
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```
     *, CMAT,          DB, DY, DS, DX, DH
      DIMENSION SOSOM(1), PP(200,3)
C****************************************
C CALCULATE DEFLECTION COEFFICIENTS *
C****************************************
      DO 220 II=1,IMAX
      SOMS=SOSOM(II)
      SOMSY=SOMS+BOMS
      ZM(1)=SOMS*EMPBW(N1)+BOMS*EMBBO(N1)
      ZQ(1)=SOMS*EMBPW(N1)+BOMS*EMBPO(N1)
      ZM(42)=ZQ(1)
      ZQ(42)=SOMS*EMPPW(N1)+BOMS*EMPPO(N1)
      ZD(83)=SOMSY*SM(N1)
      ZT(83)=SOMSY*EMRY(N1)
      ZL(124)=SOMS*EMRX(N1)
      ZD(124)=SOMSY*EMRY(N1)
      ZT(124)=SOMS*EYR(N1)+BOMS*THHO(N1)
      ZL(165)=SM(N1)*SOMS
      ZT(165)=SOMS*EMRX(N1)
      DO 135 J=1,5
      IF(CC02.AND.J.EQ.4) GO TO 135
      M=N1
      L1=J*41-40
      DO 130 I=2,N1
      L2=L1
      L1=L1+1
      M=M-1
      DB=VFLY(M)*ZB(L2)+VFLX(M)*ZS(L2)-VMY(M)*ZM(L2)-VMX(M)*ZQ(L2)
     *-VLY(M)*ZL(L2)-VLX(M)*ZD(L2)
      DS=VFLX(M)*ZB(L2)+VFDX(M)*ZS(L2)-VMX(M)*ZM(L2)-VQX(M)*ZQ(L2)
     *-VLX(M)*ZL(L2)-VDX(M)*ZD(L2)
      DY=DFLY(M)*ZB(L2)+DFLX(M)*ZS(L2)-DPMY(M)*ZM(L2)-DPMX(M)*ZQ(L2)
     *-DPLY(M)*ZL(L2)-DPLX(M)*ZD(L2)-DTY(M)*ZT(L2)
      DX=DFLX(M)*ZB(L2)+DFDX(M)*ZS(L2)-DPMX(M)*ZM(L2)-DPQX(M)*ZQ(L2)
     *-DPLX(M)*ZL(L2)-DPDX(M)*ZD(L2)-DTX(M)*ZT(L2)
      DH=WFL(M)*ZB(L2)+WFD(M)*ZS(L2)-DTY(M)*ZL(L2)-DTX(M)*ZD(L2)-WT(M)*
     *ZT(L2)
      ZB(L1)=ZB(L2)+DB
      ZS(L1)=ZS(L2)+DS
      ZY(L1)=ZY(L2)+DY
      ZX(L1)=ZX(L2)+DX
      ZH(L1)=ZH(L2)+DH
      ZL(L1)=ZL(L2)+SOMS*(EMRX(M)*ZH(L1)+SM(M)*ZY(L1))
      ZD(L1)=ZD(L2)+SOMSY*EMRY(M)*ZH(L1)+SOMSY*SM(M)*ZX(L1)
 1000 CONTINUE
      ZM(L1)=F(M)*DY+FTX(M)*DH+ZM(L2)+ZBAR(M)*ZL(L2)
     *+(SOMS*EMBBW(M)+BOMS*EMBBO(M))*ZB(L1)+(SOMS*EMBPW(M)+BOMS*EMBPO(M)
     *)*ZS(L1)
      ZQ(L1)=F(M)*DX+FTY(M)*DH+ZQ(L2)+ZBAR(M)*ZD(L2)
     *+(SOMS*EMBPW(M)+BOMS*EMBPO(M))*ZB(L1)
     *+(SOMS*EMPPW(M)+BOMS*EMPPO(M))*ZS(L1)
      ZT(L1)=FTX(M)*DB+FTY(M)*DS+ZT(L2)+(SOMS*EYR(M)+BOMS*THHO(M))*ZH(L1
     *)+SOMSY*EMRY(M)*ZX(L1)+SOMS*EMRX(M)*ZY(L1)
C
 130  CONTINUE
 135  CONTINUE
C*******************************
C CALCULATE BOUNDRY DEFLECTIONS *
```

```
C********************************
      K=N1-41
  150 KK=0
      DO 220 IA=KIN,KAX
      KK=KK+1
      L=K
      DO 200 J=1,MM5
      L=L+41
      IF(CCO2) GO TO 193
C  TORSION COMPONENT BOUNDARY CONDITION
      CMAT(5,J)=ZT(L-LPH)-FPH*(ZT(L-LPH)-ZT(L-LPHP1))
     1 -CK*(ZH(L-LPH)-FPH*(ZH(L-LPH)-ZH(L-LPHP1))        )
      GO TO 197
  193 IF(J.EQ.4)  L=L+41
  197 CONTINUE
      GO TO (400,500,600),IA
  400 CONTINUE
C  BOUNDARY CONDITIONS FOR COLLECTIVE MODES
      CMAT(1,J) = ZL(L) -ZY(L) *(VSOF +SOMS *VMAS)
      CMAT(2,J) = ZX(L)
      CMAT(3,J) = ZB(L)
      CMAT(4,J) = ZO(L) -ZS(L) * TORSO *1.E6
      GO TO     200
  500 CONTINUE
C  BOUNDARY CONDITIONS FOR CYCLIC MODES
      CMAT(1,J) = ZY(L)
      CMAT(2,J) = ZD(L) - ZX(L) *(HSOF +SOMS *HMAS)
      CMAT(3,J) = ZM(L) - ZB(L) *RSOF
      CMAT(4,J) = ZS(L)
      GO TO     200
  600 CONTINUE
      CMAT(1,J) = ZY(L)
      CMAT(2,J) = ZX(L)
      CMAT(3,J) = ZB(L)
      CMAT(4,J) = ZS(L)
      IF(CHOFF.EQ.0.0) GO TO 300
      CMAT(2,J)=ZX(L-LCH)-FCH*(ZX(L-LCH)-ZX(L-LCHP1))
      CMAT(4,J)=ZO(L-LCH)-FCH*(ZO(L-LCH)-ZO(L-LCHP1))
     1 - SOFI*(ZS(L-LCH)-FCH*(ZS(L-LCH)-ZS(L-LCHP1))       )
      ZS(LCH)=0.0
  300 CONTINUE
      IF(FHOFF.EQ.0.0) GO TO 305
      CMAT(1,J)=ZY(L-LFH)-FFH*(ZY(L-LFH)-ZY(L-LFHP1))
      CMAT(3,J)=ZM(L-LFH)-FFH*(ZM(L-LFH)-ZM(L-LFHP1))
     1-RSOF *(ZB(L-LFH)-FFH*(ZB(L-LFH)-ZB(L-LFHP1))      )
  305 CONTINUE
  200 CONTINUE
      IF(DET)  RETURN
  220 CALL INVDET(PP(II,KK))
      RETURN
      END
```

OS/360 FORTRAN H

```
  OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE INPT(TYCE,FIRST)
C*************************************************************
C        THIS SUBROUTINE READS AND PRINTS OUT INPUT DATA        *
C*************************************************************
      COMMON /COMA/ JHUB, N1,       LOT,POUT,ITLE(19),NAME(2),ND(2),NPG
     *,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41),INPUN
      COMMON /COMB/ CK, IRCOL, XRCOL(10), IBOM, RBOM(10) ,
     * SMZ(41), ZBAR(40), EYEB(120),
     * EYEC(120),SB(40), SC(40), VMB(40), VMC(40), VFB(40), VFC(40),
     * DFB(40), DFC(40), TH(41), THE(40), WT(40), SM(42),ISOM,XQSOM(200)
     *,AZBAR,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC,CHORD
     *,RB(41),RC(41)
      COMMON /BIRD/ DUMMY(63),M(6),
     1    WTPL(21),FIB(20),FIC(20),GA(20),GI(20),
     * THD(21)
      COMMON /COMC/ N,IER(7),OFFSET
      COMMON /COMF/ SOMM, TWIST, DIA, SOMI, DELSOM
      COMMON /COMH/ SPRIP     ,FLPSPR
     *,VSOF ,VMAS ,HSOF ,HMAS ,RSOF
     1,SOFI
     *,TORSO
     1,ANGLE,STR
     1,ILOC,TANALF
      COMMON /HINGES/ LCH,LCHP1,LFH,LFHP1 ,CHOFF,FHOFF,FCH,FFH,IPUNCT
     * ,RPMPUN,COLPUN
     *,LPH,LPHP1,PHOFF,FPH
     *,BOMM,TWSM ,LDYN5
     *,LOTS
     *,BOMI,TWSI,DELBOM,DELTWS
      COMMON /COMJ/ HSOFT,HMASS,VSOFT,VMASS,RSOFT
     1,SPRLG
      COMMON /COMT/ EYX(41), EYB(41), EYC(41), YB(41), YC(41), XIMI(41),
     * XIT(41), EYR(41), EMRB(41), EMRC(41), EMRR(41), EMRSQ(41), CCO2
     *,OVPLT,OVLIN,SVLIN
     *,       BLADES,HUBTYP
      LOGICAL      LTWS, LZBAR, LEIB, LEIC, LGA, LGAMB, LGI, LGAMC,
     *FIRST, LOT, POUT, LEYB, LEYC, LGAM, CCO2
     *,OVPLT,OVLIN,SVLIN
     *,SOUTH
     *,LDYN5
     *,LOTS
      DIMENSION  W(21),RHOIXX(21),RHOIYY(21)
      DATA IASK,IPLS/'*','+'/
     1,IYM/'E'/
     *,SOUTH/.FALSE./
      DATA NDECK/'DECK'/, NNAME/'NAME'/, NPLOT/'PLOT'/, NMODE/'MODE'/
     *  ,NPUNCH/'PUNC'/, NTOR/'TORS'/, NTWIST/'TWIS'/
     *,NDYN5/'DYN5'/
     *,NALLMD/'ALLM'/
      NAMELIST /INPUT/   SOMI, SOMM, DELSOM, BOMI, BOMM, DELBOM, R, JHUB
     *, N, LTWS, TWSI, TWSM, DELTWS, TWIST, THD,
     *  WTPL,ZBAR,EIB,EIC,GA,EYEB,EYEC,GI,SB,SC,RB,RC
     *,CCO2,OVPLT,OVLIN,SVLIN
     *,SPRIP    ,FLPSPR
     *,TORSO
     *,VSOFT,VMASS,HSOFT,HMASS,RSOFT
```

```
     * ,CHOFF,FHOFF
     1,SPRLG,CYCLE,AZBAR,BLADES
     *,PHOFF
     2,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC
     1,CK      ,ANGLE,STR
     *,PSQR,PLAST,DP
     1,HUBTYP
     1,ITLE,NAME
     *,Z
 1    CONTINUE
      OVPLT=.FALSE.
      OVLIN=.FALSE.
      SVLIN = .FALSE.
      LZBAR=.FALSE.
      LEIB =.FALSE.
      LEIC =.FALSE.
      LGA   =.FALSE.
      LOTS=.FALSE.
      LGAMB=.TRUE.
      LGAMC=.TRUE.
      LEYB =.FALSE.
      LEYC =.FALSE.
      LGI   =.FALSE.
C*****************
      N = 20
      Z(41)=0.0
C READ TITLE CARD *
C*****************
      IF( LOT.AND.SOUTH) GO TO 500
      SOUTH=.TRUE.
   10 READ(5,901,END=320)M
  901 FORMAT(A4,6X,A4,6X,A4,6X,A4,6X,A4,6X,A4)
      K = IYM
      LOT = .FALSE.
      POUT = .FALSE.
      INPUN = 0
      CCO2 = .TRUE.
      LTWS = .FALSE.
      LDYN5= TRUE.
      DO 965 I=1,6
      IF(M(I).EQ.NDECK)K=IASK
      IF(M(I).EQ.NNAME)K=IPLS
      IF(M(I).EQ.NMODE)POUT=.TRUE.
      IF(M(I).EQ.NALLMD)LOTS =.TRUE.
      IF(M(I).EQ.NPLOT)LOT=.TRUE.
      IF(M(I).EQ.NPUNCH)INPUN=1
      IF(M(I).EQ.NTOR)CCO2=.FALSE.
      IF(M(I).EQ.NTWIST)LTWS=.TRUE.
      IF(M(I).EQ.NDYN5)LDYN5=.FALSE.
  965 CONTINUE
      IF(K.EQ.IYM) GO TO 320
      NPG=0
      IF(K.EQ.IASK) GO TO 20
      IF (K .NE. IPLS) GO TO 10
C********************************
C READ CHANGES TO PREVIOUS CASE *
C********************************
      TWIST = TWSAVE
```

```
      READ(5,INPUT)
      IF(OVLIN) BOMI=AMAX1(1.,BOMI)
      GO TO 502
C       SET UP FOR UNCOUPLED MODES FOR FAN PLOT
  500 BOMI=1
        DELBOM=RPMA
      SOUTH=.FALSE.
        SVLIN=.TRUE.
      TWSI=1.
      TWSM=1.
      TWSAVE = TWIST
      TWIST=0.
      OVPLT=.TRUE.
      OVLIN=.TRUE.
      SOMI=.2
      DELSOM=0.05*RPMA
      GO TO 50
C*********************
C READ IN NEW CASE *
C*******************
   20 READ(5,902)NAME,(ITLE(I),I=1,10)
  902 FORMAT(4X,A4,A2,20X,10A4)
      IF(INPUN.EQ.1)WRITE(7,600)NAME,(ITLE(I),I=1,10)
  600 FORMAT(10X,A4,A2,9X,10A4)
      READ(5,904) CYCLE,TORSO,VMASS,HMASS,VSOFT,HSOFT,RSOFT
      SPRIP = HSOFT
      FLPSPR = RSOFT
      JHUB = IFIX(CYCLE)
      READ (5,  2) AZBAR,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC,TWIST,
     *  BLADES,CHORD,PSQR,DP,PLAST,HUBTYP
     * ,CHOFF,FHOFF
     1,SPRLG
     3,PHOFF,ANGLE,STR
      TWSAVE=TWIST
    2 FORMAT (14E5.0)
      DO  400 I=11,19
  400 ITLE(I)=IASK
  502 IF(AZBAR.NE.0.0) R=N*AZBAR
      BOMI = RPMA
      BOMM = RPMC
      IF(RPMC .EQ. 0.0) BOMM = RPMB
      IF(RPMB .EQ. 0.0) BOMM = RPMA
      DELBOM = 100.
      IF((BOMM-BOMI) .NE. 0.0) DELBOM = (BOMM BOMI)/2.
      TWSI = COLLA
      TWSM = COLLC
      IF(COLLC .EQ. 0.0) TWSM = COLLB
      IF(COLLB .EQ. 0.0) TWSM = COLLA
      DEL[illegible] = 10.
      IF [illegible]M-TWSI) .NE. 0.0) DELTWS = (TWSM-TWSI)/2.
      IF(P[illegible]R.EQ.0.0)PSQR=.1
      [illegible]I [illegible]QR *BOMI
      SOMM = PLAST *BOMM
      DELSOM [illegible] DP *BOMI
      IF(SOMM.LE.0.0) SOMM=10.*BOMM
      IF(DELSOM.LE.0.0) DELSOM=.25*BOMM
      IF(K.EQ.IPLS) GO TO 50
      JHUB=MAX0(JHUB,0)
```

```
      CALL DATE(ND)
      N1=N+1
      JHUB1=JHUB+1
      IF(AZBAR.GT.0.0) GO TO 145
      Z(1)=0.0
      READ(5,904)(Z(I),I=2,21)
      R=0.0
      DO 147 I=1,20
      ZBAR(I)=Z(I+1)-Z(I)
      R=R+ ZBAR(I)
C
  147 CONTINUE
  145 CONTINUE
      READ(5,904) DUMMY
  602 FORMAT(7F10.4)
      READ (5,901) DUM
  904 FORMAT(7F10.0)
      FLPINT=0.0
      TOTMAS=0.0
      Z(1)=0.0
      DO  960 ISEG=1,20
      WTPL(ISEG)=DUMMY(ISEG+42)
      EIB(ISEG)=DUMMY(ISEG+1)*10**6
      EIC (ISEG)=DUMMY(ISEG+22)*10**6
      GA(ISEG)=1.*10**6
      I=ISEG
      IF(AZBAR.NE.0.0)Z(I+1)=Z(I)+AZBAR
      TOTMAS=TOTMAS+WTPL(I)
      FLPINT=FLPINT+WTPL(I)*(R*(2*I-1)/40.)**2
  960 CONTINUE
       WTPL(21)=DUMMY(63)
      TOTMAS=TOTMAS*R/20. + WTPL(21)
      FLPINT=FLPINT+WTPL(21)*R*R
      FLPINT=FLPINT/(32.2*144.)
C
C
       TIPWT=WTPL(21)
C
      IF(LTWS) READ(5,904) (THD(I),I=1,N1)
      IF(CCO2) GO TO 45
      READ (5,904) DUM   ,CK
        READ(5,904)  DUMMY
      DO 962  ISEG=1,20
      EYEB(ISEG)=DUMMY(ISEG)
      EYEC(ISEG)=DUMMY(ISEG+21)
       GI(ISEG)=DUMMY(ISEG+42)*10**6
  962  CONTINUE
      READ(5,904) (SB(I), I=1,N)
      READ(5,904) (SC(I), I=1,N)
      READ(5,904)(RB(I),I=1,N1)
      READ(5,904)(RC(I),I=1,N1)
      DO 386 I=1,20
      DUMMY(I)=EYEB(I)
      DUMMY(I+21)=EYEC(I)    +WTPL(I)*RC(I)**2/386.4
  386 CONTINUE
      DUMMY(21)=0.0
      DUMMY(42)=-1.0
C************************************
```

```
C CALCULATE PARAMETERS FOR PRINT OUT *
C*************************************
 50   IF(.NOT.CC02) GO TO 55
   45 DO 40 I=1,N1
      SB(I)=0.
      SC(I)=0.
      RB(I)=0.
      RC(I)=0.
      EYEB(I)=0.
      EYEC(I)=0.
      WT(I)=0.
 40   EYX(I)=0.
      EYX(N1)=0.
 55   JHUB1=JHUB+1
      IF(INPUN.NE.1) GO TO 57
      IF(AZBAR.EQ.0.0) WRITE(6,202)
  202 FORMAT(1H ,58HTHE INPUT MASS AND INERTIA DATA FOR UNEQUAL SEGMENT
     1LENGTH//41HHAVE BEEN RECAST BEFORE BEING PUNCHED OUT)
      WTT=0.0
      DO 205 I=1,20
      W(I)=0.0
      RHOIXX(I)=0.0
      RHOIYY(I)=0.0
      XI=(I-1)*R/20.
      XIP1=I*R/20.
      FRAC=0.0
      DO 206 J=1,20
      YJ=Z(J)
      YJP1=Z(J+1)
      IF(XI.GT.YJP1.OR.XIP1.LE.YJ) GO TO 206
      IF(XI.LE.YJP1.AND.YJP1.LE.XIP1.AND.YJ.LE.XI) FRAC=YJP1-XI
      IF(XI.LE.YJP1.AND.YJP1.LE.XIP1.AND.XI.LE.YJ.AND.YJ.LE.XIP1)
     1  FRAC=YJP1-YJ
      IF(YJ.LE.XIP1.AND.XIP1.LE.YJP1) FRAC=XIP1-YJ
      IF(YJ.LE.XI.AND.XIP1.LE.YJP1) FRAC=XIP1-XI
      W(I)=W(I)+WTPL(J)*FRAC
      RHOIXX(I)=RHOIXX(I)+EYEB(J)*FRAC
      RHOIYY(I)=RHOIYY(I)+EYEC(J)*FRAC+W(I)*RC(I)**2/386.4
  206 CONTINUE
      W(I)=W(I)*20./R
      RHOIYY(I)=RHOIYY(I)*20./R
      RHOIXX(I)=RHOIXX(I)*20./R
      WTT=WTT+W(I)
  205 CONTINUE
      W(21)=TIPWT
      WTT=WTT*R/20.  +W(21)
       RHOIXX(21)=0.0
       RHOIYY(21)=0.0
      WRITE(7,210)(W(I),I=1,21)
      WRITE (7,210)(RHOIXX(I),I=1,21)
      WRITE (7,210)(RHOIYY(I),I=1,21)
  210 FORMAT(7F10.5)
   57 CONTINUE
      CALL START(TOTMAS,FLPINT,TIPWT,R,LTWS,FIRST)
      RETURN
 320  CALL PLTIME
      CALL PLOT(0.,0.,999)
      TYCS = 1.0
      RETURN
      END
```

OS/360 FORTRAN H

```
   OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE INVDET(Q)
C  THIS SUBROUTINE INVERTS AND FINDS THE DETERMINANT OF A SQUARE MATRIX
C        STIFF      INPUT MATRIX--INVERSE UPON RETURN
C        N          ORDER OF STIFF (N BY N)
C        Q          DETERMINANT UPON RETURN
C        DET        .FALSE.--INVERT STIFF AND FIND P
C                   .TRUE.--FIND P ONLY (STIFF IS DESTROYED)
C        NSZ        SIZE OF ARRAY STIFF IN THE CALLING PROGRAM (NSZ BY NS
C        IGOOFED    RETURNS 0 FOR NO ERROR CONDITION, 1 IF OVERFLOW OR
C                   DIVIDE CHECK OCCURS, AND 2 IF MATRIX IS SINGULAR
C                     CHECK OCCURED. (NOT USED IF DET=.TRUE.)
      COMMON /COMD/ CMAT(5,5),SOMNAT(200,3),IPLN(200,3),INODE(200,3),
     1  MM3,MM4,MM5,CT(41), ST(41), IB ,IST,
     2   IBS(10,10,3),IBE(10,10,3),ISTS(10,3),ISTE(10,3)
      COMMON /COMI/ DET,MSZ, IGOOFD , SOM, OVRG
      LOGICAL DET
      INTEGER*2 NDEX
C        REAL *8 SPECIFICATION FOR IBM; COMMENTED FOR CDC VERSION.
      REAL*8 BIGA, HOLD, STIFF,P,CMAT
      DIMENSION NDEX(50)
      DIMENSION  STIFF(5,5)
      EQUIVALENCE (MSZ, N)  , (CMAT(1,1) , STIFF(1,1) )
      DATA NSZ/5/
      L=1
      IGOOFD =0
      P=1.D0
C     SEARCH FOR LARGEST ELEMENT
      DO 80 K=1,N
      IF(DET)  L=K
      IF(K.EQ.N) GO TO 45
      BIGA=0.D0
      DO 20 J=K,N
      DO 20 I=K,N
      HOLD = DABS(STIFF(I,J))
      IF(BIGA.GE.HOLD) GO TO 20
      BIGA = HOLD
      IROW =I
      JCOL =J
 20   CONTINUE
C     INTERCHANGE ROWS
       NDEX(K) = JCOL * NSZ - NSZ * IROW
      IF(IROW.LE.K) GO TO 35
      DO 30 I=L,N
      HOLD =-STIFF(K,I)
      STIFF(K,I) = STIFF(IROW,I)
 30   STIFF(IROW,I) = HOLD
C     INTERCHANGE COLUMNS
 35   IF(JCOL.LE.K) GO TO 45
      DO 40 J=L,N
      HOLD = -STIFF(J,K)
      STIFF(J,K) = STIFF(J,JCOL)
 40   STIFF(J,JCOL) = HOLD
C     DIVIDE COLUMN BY MINUS PIVOT
 45   BIGA =-STIFF(K,K)
      IF(BIGA.EQ.0.D0)  GO TO 160
      DO 55 IC=L,N
```

```
 55   IF(IC.NE.K) STIFF(IC,K) = STIFF(IC,K)/BIGA                      INVD0570
C     REDUCE MATRIX                                                    INVD0580
      DO 65 I=1,N                                                      INVD0590
      IF(I.EQ.K ) GO TO 65                                             INVD0600
      DO 60 J=1,N                                                      INVD0610
 60   IF(J.NE.K) STIFF(I,J) = STIFF(I,K)*STIFF(K,J)+STIFF(I,J)         INVD0620
 65   CONTINUE                                                         INVD0630
      IF(DET)  GO TO 77                                                INVD0640
C     DIVIDE ROW BY PIVOT                                              INVD0650
      DO 75 JR=1,N                                                     INVD0660
 75   IF(JR.NE.K ) STIFF(K,JR) = STIFF(K,JR)/STIFF(K,K)                INVD0670
C     REPLACE PIVOT BY RECIPROCAL                                      INVD0680
 77   P=P*STIFF(K,K)                                                   INVD0690
      Q=P                                                              INVD0700
      IF(DET.AND.K.EQ.N)  RETURN                                       INVD0710
 80   STIFF(K,K) = 1.D0/STIFF(K,K)                                     INVD0720
C     FINAL ROW AND COLUMN INTERCHANGE                                 INVD0730
      K=N                                                              INVD0740
 100  K=K-1                                                            INVD0750
      IF(K.LE.0) GO TO 150                                             INVD0760
      J = ( NDEX(K) - 1) / NSZ                                         INVD0770
      IROW =  NDEX(K) - J * NSZ                                        INVD0780
      IF(IROW.LE.K) GO TO 120                                          INVD0790
      DO 130 I=1,N                                                     INVD0800
      HOLD = STIFF(I,K)                                                INVD0810
      STIFF(I,K) = -STIFF(I,IROW)                                      INVD0820
 130  STIFF(I,IROW) = HOLD                                             INVD0830
 120  JCOL =J+1                                                        INVD0840
      IF(JCOL.LE.K) GO TO 100                                          INVD0850
      DO 110 J=1,N                                                     INVD0860
      HOLD= STIFF(K,J)                                                 INVD0870
      STIFF(K,J) = -STIFF(JCOL,J)                                      INVD0880
 110  STIFF(JCOL,J) = HOLD                                             INVD0890
      GO TO 100                                                        INVD0900
 150  CONTINUE                                                         INVD0910
      RETURN                                                           INVD0920
 160  CONTINUE                                                         INVD0930
      Q = 0.0                                                          INVD0940
      RETURN                                                           INVD0950
      END                                                              INVD0960
```

OS/360 FORTRAN H

```
   OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE ITER(IM,SOM4,SOM5,P4,P5)
C*****************************************************************
C THIS SUBROUTINE ITERATES TO THE NATURAL FREQUENCY              *
C                                                                *
C        IM=MODE USED AS ARGUMENT IN CALL TO COEF                *
C        SOM4 AND SOM5= SQUARES OF FREQUENCIES THAT              *
C                       BRACKET NATURAL FREQUENCY                *
C        P4 AND P5= DETERMINANTS OF BOUNDARY CONDITION            *
                    MATRICIES ASSOCIATED WITH SOM4 AND           *
C                   SOM5                                         *
C*****************************************************************
      COMMON /COMI/ DET,MSZ, IGOOFD , SOM, OVRG
      LOGICAL XF,OVRG
      DIMENSION S(1), P(1,1)
      OVRG=.TRUE.
      XF=P4.LT.0.
      P1=ABS(P4)
      P2=-ABS(P5)
      SOM1=SOM4
      SOM2=SOM5
      S(1)=.5*(SOM1+SOM2)
      ICOUNT=0
  350 CALL COEF(IM,IM,.FALSE.,1,S,P)
      IF(P(1,1).EQ.0.)  GO TO 380
      IF(XF)  P(1,1)=-P(1,1)
      SOMTP=S(1)
      IF(P(1,1).LT.P1)  GO TO 40
   35 S(1)=.5*(SOMTP+SOM2)
      GO TO 30
   40 IF(P(1,1).GT.P2)  GO TO 50
   45 S(1)=.5*(SOM1+SOMTP)
      GO TO 30
   50 DP=ABS(P1/P2)
      IF(DP.LT.1.E5.AND.DP.GT.1.E-5)  GO TO 60
      IF(P(1,1).GT.0.)  GO TO 35
      GO TO 45
   60 X1=SOM2-SOM1
      X2=(S(1)-SOM1)/X1
      X4=P(1,1)-P1
      X5=X2*(P2-P1)-X4
      IF(ABS(X5).GT.0.001*ABS(X4))  GO TO 10
      X2=P1/(P1-P2)
      GO TO 20
   10 X3=X2*(X2-1.)/X5
      D=-P1*X3
      C=.5*([illegible]+P2*X3+1.)
      E=SQRT(C*C-D)
      X2=C-E
      IF(X2.LT.0.)  X2=C+E
   20 S(1)=SOM1+X2*X1
   30 ICOUNT=ICOUNT+1
      IF(ABS((S(1)-SOMTP)/SOMTP).LE..002 )  GO TO 380
      IF(ICOUNT.GT.20) GO TO 370
      IF(SOMTP.LT.S(1))  GO TO 360
      SOM2=SOMTP
      P2=P(1,1)
```

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```
      GO TO 350
  360 SOM1=SOMTP
      P1=P(1,1)
      GO TO 350
  370 WRITE(6,901) SOM1,SOM2,SOMTP, P1     , P2, P(1,1)
  901 FORMAT ( 20H CONVERGENCE FAILURE ,13X,1H1,20X,1H2,20X,1H3 /
     1     T21, 3HSOM , 3E20.8 / T22,1HP , 3E20.8 )
      QVRG=.FALSE.
  380 SOM=S(1)
      RETURN
      END
```

OS/360 FORTRAN H

```
 OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
           SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE MDPLOT(B,K,IMODE,KEND,F,RPM)                              MDPL0010
      DIMENSION X(63),Y(63),B(3,1),TITLF(6),WORDS(3,3)                     MDPL0020
      DATA X /3*0.00,3*0.06,3*0.12,3*0.18,3*0.24,                          MDPL0030
     $        3*0.30,3*0.36,3*0.42,3*0.48,3*0.54,                          MDPL0040
     $        3*0.60,3*0.66,3*0.72,3*0.78,3*0.84,                          MDPL0050
     $        3*0.90,3*0.96,3*1.02,3*1.08,3*1.14,3*1.20 /                  MDPL0060
      DATA N /63/,NR/3/,ISCALE/1/                                          MDPL0070
      DATA TITLE /'    ',' /R','EV  ',3*'    '/,                           MDPL0080
     *   WORDS /'COLL','ECTI','VE  ','CYCL','IC  ','    ',                 MDPL0090
     *     'SCIS','SOR ','    ' /                                          MDPL0100
      DO 100 I=1,21                                                        MDPL0110
      IT = 3*I                                                             MDPL0120
      Y(IT-2) = -B(1,I)                                                    MDPL0130
      Y(IT-1) = -B(2,I)                                                    MDPL0140
      Y(IT) = -B(3,I)/10.                                                  MDPL0150
  100 CONTINUE                                                             MDPL0160
      OMEGA = F/RPM                                                        MDPL0170
      CALL CORE (A,4)                                                      MDPL0180
      WRITE (6,3) OMEGA                                                    MDPL0190
    3 FORMAT (F4.2)                                                        MDPL0200
      TITLE(1) = A                                                         MDPL0210
      DO 200 J=1,3                                                         MDPL0220
      TITLE(J+3) = WORDS(J,IMODE)                                          MDPL0230
  200 CONTINUE                                                             MDPL0240
      KB =  MOD(K,4)                                                       MDPL0250
      IF(KB .EQ. 0) KB = 4                                                 MDPL0260
      IPRNT = 0                                                            MDPL0270
      IF(KB .EQ. 4 .OR. K .EQ. KEND) IPRNT = 1                             MDPL0280
      CALL XYPLOT(Y,X,N,NR,ISCALE,KB,IPRNT,TITLF)                          MDPL0290
      RETURN                                                               MDPL0300
      END                                                                  MDPL0310
```

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OS/360 FORTRAN H

```
 OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                  SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE MINMAX (X,XMAX,XMIN,N,PRANG,PRINCH,J,K)
      DIMENSION X(1 )
      XMAX = X(1)
      XMIN = X(1)
      DO 100 I=2,N
      IF(XMAX-X(I))3,4,4
    3 XMAX = X(I)
      GO TO 100
    4 IF(XMIN-X(I))100,100,5
    5 XMIN = X(I)
  100 CONTINUE
      IF(XMAX  * XMIN) 1,1,2
    2 IF(XMAX) 6,1,7
    6 XMAX = 0.0
      GO TO 1
    7 XMIN = 0.0
    1 CONTINUE
      XR = XMAX -XMIN
      IF(XR .EQ. 0.) XR =1.
      UPIM = XR / PRANG
      JSH = 1
      IF(UPIM .LT. 1) JSH = 0
      J = IFIX(ALOG10(UPIM)) +JSH
      PWR = 10.**J
      PRINCH = .1*PWR
      K = 1
      IF(PRINCH .GE. UPIM) GO TO 10
      PRINCH = .2 *PWR
      K = 2
      IF(PRINCH .GE. UPIM) GO TO 10
      PRINCH = .5 *PWR
      K = 3
      IF(PRINCH .GE. UPIM) GO TO 10
      PRINCH = PWR
      K = 1
      RETURN
   10 CONTINUE
      J = J-1
      RETURN
      END
```

OS/360 FORTRAN H

```
   OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                 SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE PLOUT
C****************************************
C THIS SUBROUTINE PRODUCES FAN PLOTS *
C****************************************
      COMMON /COMA/ JHUB, N1,        DUMB, POUT, ITLE(19), NAME(2), ND(2)
     *,NPG,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41)
     *,INPUN
      COMMON /COMB/ CK, IRCOL, XRCOL(10), IBOM, RBOM(10) ,
     * SMZ(41), ZBAR(40), EYEB(120),
     * EYEC(120),SB(40), SC(40), VMB(40), VMC(40), VFB(40), VFC(40),
     * DFB(40), DFC(40), TH(41), THE(40), WT(40), SM(42),ISOM,XOSOM(200)
     *,AZBAR,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC,CHORD
     *,RB(41),RC(41)
      COMMON /COMD/ CMAT(5,5),SOMNAT(200,3),IPLN(200,3),INODE(200,3),
     1  MM3,MM4,MM5,CT(41), ST(41), IB ,IST,
     2   IBS(10,10,3),IBE(10,10,3),ISTS(10,3),ISTE(10,3)
      COMMON /COMF/ SOMM, TWIST, DIA, SOMI, DELSOM
      COMMON /HINGES/ LCH,LCHP1,LFH,LFHP1 ,CHOFF,FHOFF,FCH,FFH,IPUNCT
     * ,RPMPUN,COLPUN
     *,LPH,LPHP1,PHOFF,FPH
     *,BOMM,TWSM ,LDYN5
     *,LOTS
     *,BOMI,TWSI,DELBOM,DELTWS
      COMMON /COMJ/ HSOFT,HMASS,VSOFT,VMASS,RSOFT
     1,SPRLG
      COMMON /COMT/ EYX(41), EYB(41), EYC(41), YB(41), YC(41), XIMI(41),
     * XIT(41), EYR(41), EMRB(41), EMRC(41), EMRR(41), EMRSO(41), CCO2
     *,OVPLT,OVLIN,SVLIN
     *,      BLADES,HUBTYP
C        REAL *8 SPECIFICATION FOR IBM; COMMENTED FOR CDC VERSION.
      REAL *8  CMAT
      LOGICAL OPEN, CCO2, OVPLT, OVLIN
      DIMENSION IBUFF(4096), XM(4), YM(4), X(200), Y(200)
      DIMENSION U(10), V(10), JQ1(10), JQ2(10), JQ3(10)
      DIMENSION ITLE1(10) ,ITLE2(9)
      EQUIVALENCE (ITLE(1),ITLE1(1)) ,(ITLE2(1),ITLE(11))
      DATA OPEN /.FALSE./
      SUMHIN=FHOFF+CHOFF
      IF(SUMHIN.NE.0.0) GO TO 100
      IF(OVPLT.OR.OVLIN)  CALL PLOT(-27.,0.,-3)
      GO TO 105
  100 IF(OVPLT .OR. OVLIN) CALL PLOT (-9.,0.,-3)
  105 CONTINUE
      IF(OVLIN) GO TO 450
      IF(OVPLT)  GO TO 3
      IF(OPEN) GO TO 2
      CALL PLOTS(IBUFF,4096)
      OPEN=.TRUE.
      CALL PLOT(0.5,0.,-3)
 2    XM(1)=0.
      XM(2)=DBOM(IBOM)+100.
      MAXX=MINO(15,2*(IFIX(XM(2)*.01+.9)-IFIX(XM(1)*.01+.01)))
      XMAX = 4.
      XMIN=.5+IFIX((8.1-XMAX)*.5)
      XM(3)=0.0
      XM(4)=100.
```

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      IF(DBOM(IBOM) .GT. 400.)XM(4) = 200.                             PLOU0570
      IF(DBOM(IBOM) .GT. 800.)XM(4) = 800.                             PLOU0580
      XMX=XM(3)+XMAX*XM(4)                                             PLOU0590
      YM(1)=SOMI                                                       PLOU0600
      YM(2)=SOMM+DELSOM                                                PLOU0610
      MAXY=MIN0(7,IFIX(YM(2)*.01+.9)-IFIX(YM(1)*.01+.01))              PLOU0620
      YMAX=MAXY                                                        PLOU0630
      YM(3)=0.0                                                        PLOU0640
      YM(4)=4.*XM(4)                                                   PLOU0650
      YMX=YM(3)+YMAX*YM(4)                                             PLOU0660
      SF=XM(4)/YM(4)                                                   PLOU0670
    3 DO 435 I=1,3                                                     PLOU0680
      IF(I.NE.3.AND.FHOFF.NE.0) GO TO 435                              PLOU0690
      IF(I.NE.3.AND.CHOFF.NE.0) GO TO 435                              PLOU0700
      IF(OVPLT) GO TO 7                                                PLOU0710
      CALL PLOT(-.5,0.0,3)                                             PLOU0720
      NBLD=BLADES                                                      PLOU0730
      CALL PLOT( 0.,.5,2)                                              PLOU0740
      CALL AXIS(XMIN,1.,'NATURAL FREQUENCY-CPM',21,YMAX,90.,YM(3),YM(4),PLOU0750
     *10.)                                                             PLOU0760
      IF(I.EQ.1) CALL SYMBOL(3.7,1.20+YMAX,.125,'COLLECTIVE MODE',0.,15)PLOU0770
      IF(I.EQ.2) CALL SYMBOL(3.9,1.20+YMAX,.125,'CYCLIC MODE',0.,11)   PLOU0780
      IF(I.EQ.3)  CALL SYMBOL(3.8,1.20+YMAX,.125,'SCISSORS MODE',0.,13) PLOU0790
      CET=3.66-.258*FLOAT(IRCOL)                                       PLOU0800
      CALL SYMBOL(CET, 8.5, .1, 'ROOT COLLECTIVE =', 0., 17)           PLOU0810
      CET=CET+1.457                                                    PLOU0820
      DO 5 J=1,IRCOL                                                   PLOU0830
      CALL NUMBER(CET, 8.5, .1, RCOLL(J), 0., 1)                       PLOU0840
      CET=CET+.429                                                     PLOU0850
      IF(J.GE.IRCOL)  GO TO 5                                          PLOU0860
      CALL SYMBOL(CET, 8.5, .1, ',', 0., 1)                            PLOU0870
      CET=CET+.086                                                     PLOU0880
5     CONTINUE                                                         PLOU0890
      CALL SYMBOL(CET, 8.5, .1, ' DEG.', 0., 5)                        PLOU0900
      IF(.NOT.CCO2) CALL SYMBOL(2.36, 8.85,.1,3,0.,-1)                 PLOU0910
      IF(.NOT.CCO2)CALL SYMBOL(2.93,8.80,.1,'TORSION',0.,7)            PLOU0920
      CALL NUMBER(5.5,8.8,.1,TWIST,0.,1)                               PLOU0930
      CALL SYMBOL(6.01,8.8,.1,'DEG TWIST',0.,9)                        PLOU0940
      CALL SYMBOL(7.0,9.0,.1,'VSOFT=',0.,6)                            PLOU0950
      CALL NUMBER(7.75,9.0,.1,VSOFT,0.0,2)                             PLOU0960
      CALL SYMBOL(7.0,8.8,.1,'VMASS=',0.,6)                            PLOU0970
      CALL NUMBER(7.75,8.8,.1,VMASS,0.0,2)                             PLOU0980
      CALL SYMBOL(7.0,8.6,.1,'HSOFT=',0.,6)                            PLOU0990
      CALL NUMBER(7.75,8.6,.1,HSOFT,0.0,2)                             PLOU1000
      CALL SYMBOL(7.0,8.4,.1,'HMASS=',0.,6)                            PLOU1010
      CALL NUMBER(7.75,8.4,.1,HMASS,0.0,2)                             PLOU1020
      CALL SYMBOL(7.0,8.2,.1,'RSOFT=',0.,6)                            PLOU1030
      CALL NUMBER(7.75,8.2,.1,RSOFT,0.0,2)                             PLOU1040
      CALL SYMBOL(2.36,9.05,.1,2,0.,-1)                                PLOU1050
      CALL SYMBOL(2.68,9.0,.1,'HORIZ PLANE',0.,11)                     PLOU1060
      CALL NUMBER(5.58,9.0,.1,DIA,0.,1)                                PLOU1070
      CALL SYMBOL(6.01,9.0,.1,'FT. DIA',0.,7)                          PLOU1080
      CALL SYMBOL(2.36,9.25,.1,1,0.,-1)                                PLOU1090
      CALL SYMBOL(2.76,9.2,.1,'VERT PLANE',0.,10)                      PLOU1100
      CALL SYMBOL(2.25,9.4,.1,'SYM  MAX AMPLITUDE',0.,18)              PLOU1110
      CALL PLOT(2.25,9.375,3)                                          PLOU1120
      CALL PLOT(2.48,9.375,2)                                          PLOU1130
      CALL PLOT(2.68,9.375,3)                                          PLOU1140
```

```
      CALL PLOT(3.77,9.375,2)
      CALL PLOT(3.02,9.90,3)
      CALL SYMBOL(3.02,9.6,.1,ITLE2   ,0.,35)
      CALL SYMBOL(2.93, 9.8,.1,ITLE1 , 0.,37)
      CALL PLOT( 0.,9.5,3)
      CALL PLOT( 0.,10.,2)
      CALL SYMBOL(.5,10.00,.1,'BHC PROGRAM DF1758',0.,18)
      CALL SYMBOL(2.38,10.00,.15,'COUPLED ROTOR NATURAL FREQUENCIES',
     *0.,33)
      CALL SYMBOL (6.85,10.00,.1,NAME ,0.,6)
      CALL SYMBOL(7.43,10.00,.1,'(        )',0.,10)
      CALL SYMBOL(7.516,10.00,.1,ND      ,0.,8)
      CALL PLOT(8.5,10.,3)
      CALL PLOT(8.5,9.5,2)
    7 CALL PLOT(XMIN,1.,-3)
      IF(OVPLT) GO TO 60
      CALL AXIS(0.,0.,'ROTO. RPM',-9,XMAX,0.,XM(3),XM(4),10.)
      INO1=0
      INO2=0
      IF(HUBTYP.EQ.0.0.AND.NBLD.EQ.4) INO1=2
      IF(HUBTYP.EQ.0.0.AND.NBLD.EQ.4) INO2=6
      IF(HUBTYP.EQ.0.0.AND.NBLD.EQ.6) INO1=3
      DO 200 IFF=1,8
      ICMOD=NBLD*(2*IFF-1)/2
      YSPOT=IFF
      IF(I.NE.1) GO TO 210
C   THIS PATH FOR COLLECTIVE MODES
      IF(MOD(IFF,NBLD).NE.0) GO TO 210
      DELY=IFF/40.
      DELX=XMAX/40.
      XL=0.0
      YL=0.0
      DO 238 M=1,40
      MC=MOD(M,2)+2
      XL=XL+DELX
      YL=YL+DELY
      CALL PLOT(XL,YL,MC)
  238 CONTINUE
      CALL NUMBER(XMAX,YSPOT-.05,.1,YSPOT,0.,-1)
      CALL SYMBOL(XMAX+.0857,YSPOT-.05,.1,'/REV',0.,4)
      CALL PLOT(0,0,3)
  210 IF(I.NE.2) GO TO 220
C  THIS PATH FOR CYCLIC MODES
      IF(HUBTYP.EQ.1) GO TO 220
      IF(MOD(IFF,NBLD).EQ.0) GO TO 220
      IF(IFF.EQ.INO1.OR.IFF.EQ.INO2) GO TO 220
      DELY=IFF/40.
      DELX=XMAX/40.
      XL=0.0
      YL=0.0
      DO 237 M=1,40
      MC=MOD(M,2)+2
      XL=XL+DELX
      YL=YL+DELY
      CALL PLOT(XL,YL,MC)
  237 CONTINUE
      CALL NUMBER(XMAX,YSPOT-.05,.1,YSPOT,0.,-1)
      CALL SYMBOL(XMAX+.0857,YSPOT-.05,.1,'/REV',0.,4)
```

```
      CALL PLOT(0,0,3)
  220 IF(I.NE.3) GO TO 200
C   THIS PATH FOR SCISSOR MODES
      IF(HUBTYP.EQ.0.0.AND.IFF.EQ.INO1) GO TO 230
      IF(HUBTYP.EQ.0.0.AND.IFF.EQ.INO2) GO TO 230
      IF(HUBTYP.EQ.0.0) GO TO 200
      IF(HUBTYP.EQ.1.0.AND.MOD(IFF NBLD).EQ.0) GO TO 200
  230 CONTINUE
      DELY=IFF/40.
      DELX=XMAX/40.
      XL=0.0
      YL=0.0
      DO 236 M=1,40
      MC=MOD(M,2)+2
      XL=XL+DELX
      YL=YL+DELY
      CALL PLOT(XL,YL,MC)
  236 CONTINUE
      CALL NUMBER(XMAX,YSPOT-.05,.1,YSPOT,0.,-1)
      CALL SYMBOL(XMAX+.0857,YSPOT-.05,.1,'/REV',0.,4)
      CALL PLOT(0,0,3)
  200 CONTINUE
      CALL NUMBER(0.,-.6,.125,BLADES,0.,1)
      CALL SYMBOL(.5,-.6,.125,'BLADES',0.,6)
      IF(HUBTYP.EQ.0.0) CALL SYMBOL(2.,-.6,.125,'GIMBALED HUB',0.,12)
      IF(HUBTYP.EQ.1.)CALL SYMBOL(2.,-.6,.125,'HINGELESS HUB',0.,13)
 50   CONTINUE
 60   K1=3
      IF(CC02) K1=2
      DO 415 K=1,K1
      K2=0
      DO 410 IB=1,IBOM
      DO 410 IST=1,IRCOL
      J1=IBS(IST,IB,I)
      J2=IBE(IST,IB,I)
      IF(J2.LT.J1) GO TO 410
      DO 400 J=J1,J2
      IF(IPLN (J,I).NE.K)  GO TO 400
      K2=K2+1
      X(K2)=DBOM(IB)
      Y(K2)=SOMNAT(J,I)
 400  CONTINUE
 410  CONTINUE
      IF(K2.EQ.0) GO TO 415
      X(K2+1)=XM(3)
      X(K2+2)=XM(4)
      Y(K2+1)=YM(3)
      Y(K2+2)=YM(4)
      CALL LINE(X,Y,K2,1,-1,K)
 415  CONTINUE
 420  CONTINUE
      IF(OVPLT)  GO TO 430
      CALL PLOT(8.5-XMIN,-.5,3)
      CALL PLOT(8.5-XMIN,-1.,2)
 430  CALL PLOT(9.-XMIN,-1.,-3)
  435 CONTINUE
 440  CALL TIMEX(TU,TT,TL)
      ET=60.*TT
```

```
      WRITE(6,901) ET
  901 FORMAT ( 38HOPLOT REQUESTED-PROGRAM EXECUTION TIME ,F8.2,
     1 8H SECONDS )
      RETURN
  450 X(1)=XM(3)
      DX= XMAX*XM(4)/199.
      Y(1)=(X(1)-XM(3))/XM(4)
      DO 455 I=2,200
      X(I)=X(I-1)+DX
  455 Y(I)=(X(I   )-XM(3))/XM(4)
      YR2=YM(3)+YMAX*YM(4)
      K1=3
      IF(CC02) K1=2
      CALL PLOT(XMIN,1.,-3)
      DO 630 I=1,3
      IF(SUMMIN.NE.0.0.AND.I.NE.3) GO TO 630
      DO 460 IB=1,IBOM
      J01(IB)=IBS(1,IB,I)
  460 J02(IB)=IBE(1,IB,I)
      DO 620 K=1,K1
      DO 470 IB=1,IBOM
  470 J03(IB)=J01(IB)-1
  480 KNT=0.
      DO 510 IB=1,IBOM
  490 IF(J03(IB).GE.J02(IB)) GO TO 510
      J03(IB)=J03(IB)+1
      JIB = J03(IB)
      IF(IPLN (   JIB   ,I).NE.K)  GO TO 490
      KNT=KNT+1
      V(KNT)=SOMNAT(   JIB   ,I)
      U(KNT)=DBOM(IB)
  510 CONTINUE
      IF(KNT.LE.1)  GO TO 620
      C1=0.
      C2=0.
      C3=0.
      C4=0.
      DO 520 IB=1,KNT
      C5=U(IB)**2
      C6=V(IB)**2
      C1=C1+C5
      C2=C2+C6
      C3=C3+C5*C6
  520 C4=C4+C5**2
      C7=FLOAT(KNT)
      C6=(C1*C2-C3*C7)/(C1**2-C4*C7)
      C5=(C2-C1*C6)/C7
      DO 530 L=1,199
      C1=SQRT(ABS(C5+C6*X(L)**2))
      IF(C1.GE.YM(3).AND.C1.LE.YR2) GO TO 540
  530 CONTINUE
      GO TO 570
  540 CALL PLOT(Y(L),(C1-YM(3))/YM(4),3)
      J=L+1
      DO 550 L=J,200
      C1 = SQRT(ABS(C5+C6*X(L)**2))
      IF(C1.LT.YM(3).OR.C1.GT.YR2) GO TO 560
  550 CALL PLOT(Y(L),(C1-YM(3))/YM(4),2)
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560   C1=(C1-YM(3))/YM(4)
      CALL SYMBOL(XMAX+.66,C1,.1,'K=',0.,2)
      CALL NUMBER(XMAX+.83,C1,.1,C6,0.,3)
      GO TO 480
570   IF(KNT.EQ.0) GO TO 620
      DO 580 L=1,KNT
580   CALL SYMBOL((U(L)-XM(3))/XM(4),(V(L)-YM(3))/YM(4),.05,K,0.,-1)
      GO TO 480
620   CONTINUE
      CALL PLOT(9.,0.,-3)
 630  CONTINUE
      CALL PLOT(-XMIN,-1.,-3)
      GO TO 440
      END
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OS/360 FORTRAN H

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      OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE START(TOTMAS,FLPINT,TIPWT,R,LTWS,FIRST)
C*****************************************************************
C     CALCULATES COEFFICIENTS WHICH ARE INDEPENDENT OF SWEEPS *
C*****************************************************************
      COMMON /COMA/ JHUB, N1,       LOT,POUT,ITLE(19),NAME(2),ND(2),NPG
     *,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41),INPUN
      COMMON /COMB/ CK, IRCOL, XRCOL(10), IBOM, RBOM(10) ,
     * SMZ(41), ZBAR(40), EYEB(120),
     * EYEC(120),SB(40), SC(40), VMB(40), VMC(40), VFB(40), VFC(40),
     * DFB(40), DFC(40), TH(41), THE(40), WT(40), SM(42),ISOM,XQSOM(200)
     *,AZBAR,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC,CHORD
     *,RB(41),RC(41)
      COMMON /BIRD/ DUMMY(63),M(6),
     1    WTPL(21),EIB(20),EIC(20),GA(20),GI(20),
     * THD(21)
      COMMON /COMC/ N, IER(7)
     1,OFFSET
      COMMON /COMF/ SOMM, TWIST, DIA, SOMI, DELSOM
      COMMON /COMH/ SPRIP    ,FLPSPR
     *,VSOF ,VMAS ,HSOF ,HMAS ,RSOF
     1,SOFI
     *,TORSO
     1,ANGLE,STR
     1,ILOC,TANALF
      COMMON /HINGES/ LCH,LCHP1,LFH,LFHP1 ,CHOFF,FHOFF,FCH,FFH,IPUNCT
     * ,RPMPUN,COLPUN
     *,LPH,LPHP1,PHOFF,FPH
     *,BOMM,TWSM ,LDYN5
     *,LOTS
     *,BOMI,TWSI,DELBOM,DELTWS
      COMMON /COMJ/ HSOFT,HMASS,VSOFT,VMASS,RSOFT
     1,SPRLG
      COMMON /COMT/ EYX(41), EYB(41), EYC(41), YB(41), YC(41), XIMI(41),
     * XIT(41), EYR(41), EMRB(41), EMRC(41), EMRR(41), EMRSO(41), CCO2
     *,OVPLT,OVLIN,SVLIN      ,BLADES,HUBTYP
      LOGICAL      LTWS, LZBAR, LEIB, LEIC, LGA, LGAMB, LGI, LGAMC,
     *FIRST, LOT, POUT, LEYB, LEYC, LGAM, CCO2
     *,OVPLT,OVLIN,SVLIN
     *,SOUTH
     *,LDYN5
     *,LOTS
     1,OFFSET
C        REAL *8 SPECIFICATION FOR IBM; COMMENTED FOR CDC VERSION.
      REAL*8 HNGE,HNLS
      DIMENSION CF(40)
      DATA          CVR,CVRPS,HCVM /        0.0174533,
     *0.1047198, 0.00129539 /
     *,SOUTH/.FALSE./
     1  ,HNGE/8HGIMBALED/, HNLS/8H RIGID  /
      RPMPUN=BOMI
      COLPUN=TWSI
      IF(BOMI.NE.BOMM.AND.TWSI.NE.TWSM)RPMPUN=BOMI+DELBOM
      IF(BOMI.NE.BOMM.AND.TWSI.NE.TWSM)COLPUN=TWSI+DELTWS
      IF(.NOT.LDYN5) RPMPUN=RPMC
      IF(.NOT.LDYN5) COLPUN=COLLC
C
```

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C                                                                       STAR0570
      IF(DELTWS.LE.0.)  DELTWS=10.                                      STAR0580
      IRCOL=MAX0(1,IFIX((TWSM-TWSI)/DELTWS+1.01))                       STAR0590
  700 RCOLL(1)=TWSI                                                     STAR0600
      XRCOL(1)=TWSI*CVR                                                 STAR0610
      IF(IRCOL.EQ.1)  GO TO 720                                         STAR0620
      X2=DELTWS*CVR                                                     STAR0630
      DO 710 I=2,IRCOL                                                  STAR0640
      RCOLL(I)=RCOLL(I-1)+DELTWS                                        STAR0650
  710 XRCOL(I)=XRCOL(I-1)+X2                                            STAR0660
  720 BOMI=AMAX1(0.,BOMI)                                               STAR0670
      IF(DELBOM.LE.0.)  DELBOM=100.                                     STAR0680
      IBOM=MAX0(1,IFIX((BOMM-BOMI)/DELBOM+1.01))                        STAR0690
  730 IF(IBOM.LE.10)  GO TO 740                                         STAR0700
      IER(7)=1                                                          STAR0710
      IBOM=1                                                            STAR0720
  740 DBOM(1)=AMAX1(0.,BOMI)                                            STAR0730
      RBOM(1)=DBOM(1)*CVRPS                                             STAR0740
      IF(IBOM.LE.1)  GO TO 760                                          STAR0750
      X2=DELBOM*CVRPS                                                   STAR0760
      DO 750 I=2,IBOM                                                   STAR0770
      DBOM(I)=DBOM(I-1)+DELBOM                                          STAR0780
  750 RBOM(I)=RBOM(I-1)+X2                                              STAR0790
  760 IF(R.LE.O.AND..NOT.LZBAR) IER(2)=1                                STAR0800
      N1=N+1                                                            STAR0810
      CALL SETIME(550.)                                                 STAR0820
   60 CONTINUE                                                          STAR0830
      IF(AZBAR.LE.0.0) GO TO 110                                        STAR0840
      ZBAR(1)=R/FLOAT(N)                                                STAR0850
      Z(1)=0.0                                                          STAR0860
      DO 70 I=1,N                                                       STAR0870
      Z(I+1)=Z(I)+AZBAR                                                 STAR0880
   70 ZBAR(I)=ZBAR(1)                                                   STAR0890
  110 IF(JHUB.EQ.0)  GO TO 125                                          STAR0900
      DO 120 I=1,JHUB                                                   STAR0910
  120 THD(I)=0.                                                         STAR0920
  125 CONTINUE                                                          STAR0930
      FLPINT=TIPWT*R*R                                                  STAR0940
      TOTMAS=TIPWT                                                      STAR0950
   80 DO 90 I=1,N                                                       STAR0960
      TOTMAS=TOTMAS+WTPL(I)*ZBAR(I)                                     STAR0970
      FLPINT=FLPINT+(WTPL(I)*ZBAR(I)*(Z(I)+Z(I+1))**2)/4.               STAR0980
      VMB(I)=EIB(I)                                                     STAR0990
      VMC(I)=EIC(I)                                                     STAR1000
      DUMMY(I)=EIB(I)/10**6                                             STAR1010
      DUMMY(I+20)=EIC(I)/10**6                                          STAR1020
   90 CONTINUE                                                          STAR1030
      DO 85 I=1,N                                                       STAR1040
      CF(I)=0.0                                                         STAR1050
      DO 87 IJ=I,N                                                      STAR1060
      CF(I)=CF(I)+WTPL(IJ)*ZBAR(IJ)*(Z(IJ)+Z(IJ+1))*.5                  STAR1070
   87 CONTINUE                                                          STAR1080
      CF(I)=(CF(I)+TIPWT*R)*CVRPS*CVRPS/386.4                           STAR1090
   85 CONTINUE                                                          STAR1100
C                                                                       STAR1110
      FLPINT=FLPINT/(32.2*144.)                                         STAR1120
      IF(LTWS) GO TO 180                                                STAR1130
      THD(1)=0.                                                         STAR1140
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      DUM1=TWIST/R                                                      STAR1150
      DO100 I=1,N                                                       STAR1160
  100 THD(I+1)=THD(I)+ZBAR(I)*DUM1                                      STAR1170
  180 CONTINUE                                                          STAR1180
      GAMMA=0.002378*5.73*CHORD*R**4/(FLPINT*12**5)                     STAR1190
C*******************                                                    STAR1200
C PRINT OUT INPUT *                                                     STAR1210
C*******************                                                    STAR1220
      NPG=NPG+1                                                         STAR1230
      WRITE(6,905) NPG, CDATE, ND, NAME, ITLE                           STAR1240
  905 FORMAT (1H1,27X,4HPAGE,I3,12X,2^HBHC PROGRAM DF1758 -COMPILED ,   STAR1250
     1  2A4,11X,2A4 /28X,A4,A2,24X,19HNATURAL BLADE MODES //48X,10A4/49XSTAR1260
     2  ,8A4,A3 )                                                       STAR1270
      NSWEEP = IFIX((SOMM-SOMI)  /DELSOM) +1                            STAR1280
      IF(NSWEEP .LE. 200) GO TO 20                                      STAR1290
      DELSOM = (SOMM-SOMI)/199.                                         STAR1300
      NSWEEP = 200                                                      STAR1310
      WRITE (6,1) DELSOM                                                STAR1320
    1 FORMAT (80HO MORE THAN 200 POINTS REQUESTED ON FREQUENCY SWEEP. DESTAR1330
     *LTA HAS BEEN CHANGED TO    F10.4 )                                STAR1340
   20 CONTINUE                                                          STAR1350
      WRITE(6,906)(I,ZBAR(I),DUMMY(I),DUMMY(I+20),WTPL(I),THD(I),       STAR1360
     1CF(I),I=1,N)                                                      STAR1370
  906 FORMAT(36X,                                                       STAR1380
     173HSEGMENT          EI (LB-IN**2'           WT/L'      TWIST AT   STAR1390
     2      CF AT,/35X,                                                 STAR1400
     374H LENGTH       BEAM         CHORD        (LB/IN)    INBD END    STAR1410
     4   INBD END,/35X,                                                 STAR1420
     574H  (IN)        (E-6)        (E-6)                  (DEG)        STAR1430
     6    (LB/RPM),/,(29X,I2,F11.2,4G14.3,G14.5)    )                   STAR1440
      IF(N.LE.33) GO TO 190                                             STAR1450
      NPG=NPG+1                                                         STAR1460
      WRITE(6,905) NPG, CDATE, ND, NAME, ITLE                           STAR1470
  190 WRITE(6,907) R, BOMI, BOMM, DELBOM, JHUB, TWSI, TWSM, DELTWS, SOMISTAR1480
     *, SOMM, DELSOM, THD(N1)                                           STAR1490
  907 FORMAT (1HO,27X,7HRADIUS=,F7.2,3H IN,T81,24HINITIAL   FINAL   DELTSTAR1500
     1A / T70,9HROTOR RPM ,3F9.2 /28X,I2,13H HUB SEGMENTS,T64,          STAR1510
     2  15HROOT COLL (DEG) ,3F9.2 /T63 ,16HFREQ SWEEP (CPM) ,3F9.2 /28X,STAR1520
     3  13HTWIST AT TIP=,F8.3,4H DEG / )                                STAR1530
      WRITE(6,882) TIPWT,TORSO,VSOFT,VMASS,HSOFT,HMASS,RSOFT,SPRLG,     STAR1540
     1FHOFF,CHOFF,BLADES                                                STAR1550
  882 FORMAT (/29X,9HTIPWEIGHT,6X,G10.3,4H LBM,7X,13HMAST TOR STIF ,    STAR1560
     1  G10.3,11H IN-LBF/DEG //30X,5HVSOFT,10X,G10.3,5H /LBF,6X,5HVMASS,STAR1570
     2  8X,G10.3,10H LBM/BLADE //30X, 5HHSOFT,10X,G10.3,5H /LBF,6X,     STAR1580
     3  5HHMASS,8X,G10.3, 10H LBM/BLADE //30X,15HFLP SPRING/BLD ,G10.3, STAR1590
     4  24HFT-LBF/DEG INPL SPRG/BLD ,G10.3,11H FT-LBF/DEG //30X,        STAR1600
     5  15HFLP HNG OFFSET ,G10.3,5H INCH,6X,15HINPL HNG OFFSET ,G9.3,   STAR1610
     6  5H INCH //30X,15HNUMBER OF BLDS ,G10.3 )                        STAR1620
      WRITE(6,873) PHOFF                                                STAR1630
      IF(HUBTYP.EQ.1.)WRITE (6,883) HNLS,CHORD                          STAR1640
      IF(HUBTYP.NE.1.)WRITE (6,883) HNGE,CHORD                          STAR1650
C                                                                       STAR1660
  873 FORMAT (1H+,66X,17HPITCH HORN OFFSET ,F10.4,5H INCH )             STAR1670
      LPH=PHOFF/ZBAR(1)                                                 STAR1680
      FPH=(PHOFF-LPH*ZBAR(1))/ZBAR(1)                                   STAR1690
      LPHP1=LPH +1                                                      STAR1700
      LFH=FHOFF/ZBAR(1)                                                 STAR1710
      FFH=(FHOFF-LFH*ZBAR(1))/ZBAR(1)                                   STAR1720
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ORIGINAL PAGE IS
OF POOR QUALITY

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      LCH=CHOFF/ZBAR(1)
      FCH=(CHOFF- LCH*ZBAR(1))/ZBAR(1)
      LFHP1=LFH+1
      LCHP1=LCH+1
      HMAS=-HMASS*BLADES/386.4
      VMAS=-VMASS*BLADES/386.4
      IF(HSOFT.EQ.0.0)HSOF =1.E20
      IF(VSOFT.EQ.0.0)VSOF =1.E20
      IF(HSOFT.NE.0.000)HSOF =2.E7/(R*HSOFT)
      IF(VSOFT.NE.0.000)VSOF =2.E7/(R*VSOFT)
      RSOF =RSOFT*12*57.3
      SOFI=SPRLG*12*57.3
  883 FORMAT(1H0,29X,15HHUB TYPE       ,A8,14X,13HCHORD        ,F10.3,6H
     1INCHES)
      WRITE(6,802)TOTMAS,FLPINT
  802 FORMAT (/29X,10HBLADE MASS,5X,G10.3,4H LBM,9X,12HFLAP INERTIA,
     1  G10.3,17H SLUG-FT**2/BLADE  )
      WRITE(6,913) GAMMA
  913 FORMAT (/29X,17HBLADE LOCK NUMBER ,G10.3 )
 210  IF(CC02) GO TO 240
      NPG=NPG+1
      WRITE(6,905) NPG, CDATE, ND, NAME, ITLE
      WRITE(6,935)
  935 FORMAT (10X,
     1 23HIBB (IN-LB-SEC**2/IN)  29H BEAM RAD. OF GYRATION (IN)   ,
     2 23HICC (IN-LB-SEC**2/IN)  29HCHORD RAD. OF GYRATION (IN)   )
      DO 215 I=1,N
      RADBB = 0.
      RADCC = 0.
      IF(WTPL(I) .EQ. 0.0) GO TO 440
      RADBB = SQRT(EYEB(I) *386.4/WTPL(I))
      RADCC = SQRT(EYEC(I) *386.4/WTPL(I))
  440 CONTINUE
      WRITE (6,938) I,EYEB(I),RADBB,EYEC(I),RADCC
  938 FORMAT (8X,I2,6X,E15.5,8X,G14.4,15X,E15.5,8X,G14.4 )
  215 CONTINUE
  910 FORMAT (1H+,82X,2F15.2 )
      NPG=NPG+1
      WRITE(6,905) NPG, CDATE, ND, NAME, ITLE
      WRITE(6,919) CK
  919 FORMAT (46X,25HCONTROL SYSTEM STIFFNESS= ,E15.5,6H IN-LB // 33X,
     1  12HSHEAR CENTER ,8X,11HC.G. OFFSET,6X,12HGJ(LB-IN**2) / 34X,
     2  11HOFFSET(IN),12X,4H(IN) /33X,4HBEAM,4X,5HCHORD,6X,4HBEAM,4X,
     3  5HCHORD  )
      DO 230 I=1,N
      WRITE(6,931) I, SB(I), SC(I), RB(I), RC(I), GI(I)
 931  FORMAT(28XI2,2F8.3,3X,2F8.3,3X,E12.5)
  230 CONTINUE
      WRITE(6,933) RB(21),RC(21)
  933 FORMAT(28X,2HTW,19X,2F8.3)
C***********************************************************************
C CALCULATE COEFFICIENTS INDEPENDENT OF COLLECTIVE ANGLE AND ROTOR RPM
C***********************************************************************
 240  Z(1)=0.
      DO 245 I=1,N1
 245  TH(I)=THD(I)*CVR
      DO 300 I=1,N
      Z(I+1)=Z(I)+ZBAR(I)
```

```
      IF(I.LT.2.OR.I.GT.19) GO TO 352
       IF(OFFSET) GO TO 352
      TV1=(VMC(I-1)+VMC(I+1))/100.
      TV2=(VMB(I-1)+VMB(I+1))/100.
      IF(VMC(I).LT.TV1.OR.VMB(I).LT.TV2)OFFSET=.TRUE.
      IF(OFFSET)Z(41)=FLOAT(I)
  352 CONTINUE
      IF(VMB(I).GE.5.E02)VMB(I)=ZBAR(I)/VMB(I)
      IF(VMC(I).GE.5.E03)VMC(I)=ZBAR(I)/VMC(I)
      DUM1=0.
      VFB(I)=0.5*ZBAR(I)*VMB(I)
      DFB(I) = ZBAR(I) *0.6666667 *VFB(I)
      VFC(I)=0.5*ZBAR(I)*VMC(I)
      DFC(I) = ZBAR(I) *VFC(I) *0.666667
      ICOT=Z(41)
      TANALF       =TAN(ANGLE/57.3)
      ILOC=ICOT
      ANGLE=0.0
 280  IF(CCO2) GO TO 290
      WT(I)=1./GI(I)
      WT(I)=ZBAR(I)*WT(I)
 290  THE(I)=0.
      IF(VMB(I).EQ.0.0) VMB(I)=1.0
      IF(VMC(I).EQ.0.0) VMC(I)=1.0
       IF(VMB(I).LT.0.0) VMB(I)=-1./(VMB(I)*57.3*12.)
      IF(VMC(I).LT.0.0) VMC(I)=-1.0/(VMC(I)*57.3*12.)
      IF(I.GT.JHUB) THE(I)=.5*(TH(I)+TH(I+1))
      SM(I+1)=HCVM*ZBAR(I)*WTPL(I)
      IF(.NOT.CCO2)  EYX(I+1)=SM(I+1)*ZBAR(I)**2/12.
      EMRB(I+1)=0.
      EMRC(I+1)=0.
      IF(SVLIN)  GO TO 292
      EMRB(I+1)=SM(I+1)*RB(I)
      EMRC(I+1)=SM(I+1)*RC(I)
 292  EYR(I+1)=EMRB(I+1)*RB(I)+EMRC(I+1)*RC(I)
      EMRR(I+1)=4.*SM(I+1)*RB(I)*RC(I)
      EMRSQ(I+1)=SM(I+1)*(RC(I)**2-RB(I)**2)
      EYB(I+1)=.5*EYEB(I)*ZBAR(I)
 300  EYC(I+1)=.5*EYEC(I)*ZBAR(I)
      SM(1)=SM(2)
      EYX(1)=EYX(2)
      EYB(1)=EYB(2)
      EYC(1)=EYC(2)
      EYR(1)=EYR(2)
      EMRB(1)=EMRB(2)
      EMRC(1)=EMRC(2)
      EMRR(1)=EMRR(2)
      EMRSQ(1)=EMRSQ(2)
      EYR(21)=EYR(21)+TIPWT*(RC(21)**2+RB(21)**2)/386.4
      DO 301 I=2,N
      EYX(I)=EYX(I)+EYX(I+1)
      EYB(I)=EYB(I)+EYB(I+1)
      EYC(I)=EYC(I)+EYC(I+1)
      EYR(I)=EYR(I)+EYR(I+1)
      EMRB(I)=EMRB(I)+EMRB(I+1)
      EMRC(I)=EMRC(I)+EMRC(I+1)
      EMRR(I)=EMRR(I)+EMRR(I+1)
      EMRSQ(I)=EMRSQ(I)+EMRSQ(I+1)
```

```
301  SM(I)=SM(I)+SM(I+1)                                    STAR2890
     SM(21)=SM(21)+TIPWT/386.4                              STAR2900
     DO 302 I=1,N1                                          STAR2910
     EYR(I)=EYB(I)+EYC(I) +EYR(I)                           STAR2920
     YB(I)=EYX(I)+EYC(I)                                    STAR2930
     YC(I)=EYX(I)+EYB(I)                                    STAR2940
     XIMI(I)=EYC(I)-EYB(I)                                  STAR2950
302  XIT(I)=-2.*EYX(I)+EYB(I)+EYC(I)                        STAR2960
     ISOM = NSWEEP                                          STAR2970
     XSOM    =SOMI                                          STAR2980
     SMZ(N1)=0.                                             STAR2990
     J=N1                                                   STAR3000
     DO 315 I=1,N                                           STAR3010
     JP = J                                                 STAR3020
     J=J-1                                                  STAR3030
 315 SMZ(J) = SMZ(JP) +SM(JP) *Z(JP)                        STAR3040
     DO 330 I=1,ISOM                                        STAR3050
     XOSOM(I)=(XSOM*CVRPS)**2                               STAR3060
330  XSOM    =XSOM      +DELSOM                             STAR3070
     FIRST=.FALSE.                                          STAR3080
     DIA=R/6.                                               STAR3090
     RETURN                                                 STAR3100
     END                                                    STAR3110
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OS/360 FORTRAN H

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   OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE SUMMY                                                  SUMM0010
C*****************************************************************      SUMM0020
C THIS SUBROUTINE PRINTS OUT A SUMMARY OF NATURAL FREQUENCIES *         SUMM0030
C*****************************************************************      SUMM0040
      COMMON /COMA/ JHUB, N1,      LOT,POUT,ITLE(19),NAME(2),ND(2),NPG  SUMM0050
     *,CDATE(2),JHUB1,DBOM(10),RCOLL(10),Z(41),INPUN                    SUMM0060
      COMMON /COMB/ CK, IRCOL, XRCOL(10), IBOM, RBOM(10) ,              SUMM0070
     * SMZ(41), ZBAR(40), EYEB(120),                                    SUMM0080
     * EYEC(120),SB(40), SC(40), VMB(40), VMC(40), VFB(40), VFC(40),    SUMM0090
     * DFB(40), DFC(40), TH(41), THE(40), WT(40), SM(42),ISOM,XOSOM(200)SUMM0100
     *,AZBAR,RPMA,RPMB,RPMC,COLLA,COLLB,COLLC,CHORD                     SUMM0110
     *,RB(41),RC(41)                                                    SUMM0120
      COMMON /COMD/ CMAT(5,5),SOMNAT(200,3),IPLN(200,3),INODE(200,3),   SUMM0130
     1  MM3,MM4,MM5,CT(41), ST(41), IB ,IST,                            SUMM0140
     2   IBS(10,10,3),IBE(10,10,3),ISTS(10,3),ISTE(10,3)                SUMM0150
      COMMON /HINGES/ LCH,LCHP1,LFH,LFHP1 ,CHOFF,FHOFF,FCH,FFH,IPUNCT   SUMM0160
     * ,RPMPUN,COLPUN                                                   SUMM0170
     *,LPH,LPHP1,PHOFF,FPH                                              SUMM0180
     *,BOMM,TWSM ,LDYN5                                                 SUMM0190
     *,LOTS                                                             SUMM0200
     *,BOMI,TWSI,DELBOM,DELTWS                                          SUMM0210
      COMMON /COMTP/ DEG(200,3),PLNE(2,4),ODES(2,5)                     SUMM0220
C        REAL *8 SPECIFICATION FOR IBM; COMMENTED FOR CDC VERSION.      SUMM0230
      REAL *8  CMAT                                                     SUMM0240
      REAL *8 PLNE,ODES                                                 SUMM0250
      DIMENSION                SOMNA1(200), SOMNA2(200), SOMNA3(200),   SUMM0260
     *IP1(200), IP2(200), IP3(200), INO1(200), INO2(200), INO3(200),    SUMM0270
     *            IB1(10,10), IB3(10,10), IB5(10,10), IB2(10,10),       SUMM0280
     *IB4(10,10), IB6(10,10), IST1(10), IST3(10), IST5(10), IST2(10),   SUMM0290
     *IST4(10), IST6(10),ITLE1(10),ITLE2(9)                             SUMM0300
     *                .DEG1(200), DEG2(200), DEG3(200)                  SUMM0310
      EQUIVALENCE (ITLE(1),ITLE1(1)) ,(ITLE2(1),ITLE(11))               SUMM0320
      EQUIVALENCE (SOMNAT(1,1),SOMNA1( 1 )),(SOMNAT(1,2),SOMNA2(1)) ,   SUMM0330
     1            (SOMNAT(1,3),SOMNA3(1)),(IPLN(1,1),IP1(1)) ,          SUMM0340
     2            (IPLN(1,2),IP2(1)) , (IPLN(1,3),IP3(1)) ,             SUMM0350
     3            (INODE(1,1),INO1(1)) , (INODE(1,2),INO2(1)) ,         SUMM0360
     4            (INODE(1,3),INO3(1)),(IBS(1,1,1),IB1(1,1)),           SUMM0370
     5            (IBS(1,1,2),IB3(1,1)), (IBS(1,1,3),IB5(1,1)),         SUMM0380
     6            (IBE(1,1,1),IB2(1,1)), (IBE(1,1,2),IB4(1,1)),         SUMM0390
     7            (IBE(1,1,3),IB6(1,1)), (ISTS(1,1),IST1(1)) ,          SUMM0400
     8            (ISTS(1,2),IST3(1)) , (ISTS(1,3),IST5(1)) ,           SUMM0410
     9            (ISTE(1,1),IST2(1)) , (ISTE(1,2),IST4(1)) ,           SUMM0420
     A            (ISTE(1,3),IST6(1))                                   SUMM0430
      EQUIVALENCE (DEG(1,1),DEG1(1)) , (DEG(1,2),DEG2(1)) ,             SUMM0440
     1            (DEG(1,3),DEG 3(1))                                   SUMM0450
      IF(FHOFF.NE.0.OR.CHOFF.NE.0) GO TO 3                              SUMM0460
      NPG=NPG+1                                                         SUMM0470
      WRITE(6,901) NPG,CDATE,ND,NAME,ITLE1,NAME,ITLE1,ITLE2,ITLE2       SUMM0480
  901 FORMAT (1H1,27X,4HPAGE,I3,12X,29HBHC PROGRAM DF175R -COMPILED ,   SUMM0490
     1  2A4,11X,2A4 /57X,19HNATURAL BLADE MODES //1X,2(9X,A4,A2,4X,9A4, SUMM0500
     2  A1,10X) /1X,2(20X,8A4,A3,11X) //19X,30HC O L L E C T I V E   M OSUMM0510
     3 D E ,40X,22HC Y C L I C   M O D E / 2(5X,20HNATURAL  ROOT  ROTOR,SUMM0520
     4  4X,19HMAXIMUM   NUMBER OF,5X,3HMAX,10X ) /                      SUMM0530
     5  2(6X,4HFREQ,4X,4HCOLL,3X,3HRPM,4X,9HAMPLITUDE,4X,5HNODES,4X,    SUMM0540
     6  10HDEFLECTION ,6X) / 2(5X,4H/REV,5X,3HDEG,33X,10HANGLE--DEG,6X))SUMM0550
      LINES=0                                                           SUMM0560
```

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```
      IN1=1
      IN2=1
      DO 60  IST=1,IRCOL
      IF(IST2(IST).LT.IST1(IST).AND.IST4(IST).LT.IST3(IST))
     *  GO TO 60
      LINES=LINES+1
      WRITE(6,902)
  902 FORMAT (1H  )
      DO 50  IB=1,IBOM
      IF(IB2(IST,IB).LT.IB1(IST,IB).AND.IB4(IST,IB).LT.IB3(IST,IB))
     *   GO TO 50
      WRITE(6,902)
      LINES=LINES+1
      MB=IB2(IST,IB)-IB1(IST,IB)+1
      MC=IB4(IST,IB)-IB3(IST,IB)+1
      MA=MAX0(MB,MC)
      IF(LINES.EQ.2.OR.LINES+MA.LE.50) GO TO 20
      NPG=NPG+1
      WRITE(6,901) NPG,CDATE,ND,NAME,ITLE1,NAME,ITLE1,ITLE2,ITLE2
      WRITE(6,903)
 903  FORMAT(1H0)
      LINES=2
 20   LINES=LINES+MA
      DO 40  I=1,MA
      WRITE(6,902)
      IF( I.GT.MB) GO TO 30
      SOMNA1(IN1)=SOMNA1(IN1)/DBOM(IB)
      IP = IP1(IN1)
      IN = INO1(IN1)
      WRITE(6,904) SOMNA1(IN1), RCOLL(IST), DBOM(IB), (PLNE(J,IP),
     *J=1,2), (ODES(K,IN)        , K=1,2), DEG1(IN1)
      SOMNA1(IN1)=SOMNA1(IN1)*DBOM(IB)
  904 FORMAT (1H+,F10.5,2F7.1,2X,A8,A3,2X,A8,A2,F7.1)
      IN1=IN1+1
 30   IF(I.GT.MC) GO TO 40
      SOMNA2(IN2)=SOMNA2(IN2)/DBOM(IB)
      IP = IP2(IN2)
      IN = INO2(IN2)
      WRITE(6,905) SOMNA2(IN2), RCOLL(IST), DBOM(IB), (PLNE(J,IP),
     *J=1,2), (ODES(K,IN)        , K=1,2), DEG2(IN2)
      SOMNA2(IN2)=SOMNA2(IN2)*DBOM(IB)
  905 FORMAT (1H+,F76.5,2F7.1,2X,A8,A3,2X,A8,A2,F7.1)
      IN2=IN2+1
 40   CONTINUE
 50   CONTINUE
 60   CONTINUE
    3 CONTINUE
      WRITE(6,907) NPG,CDATE,ND,NAME,ITLE1,          ITLE2
  907 FORMAT (1H1,27X,4HPAGE,I3,12X,29HBHC PROGRAM DF1758 -COMPILED ,
     1  2A4,11X,2A4 /57X,19HNATURAL BLADE MODES //10X,A4,A2,4X,9A4,A1 /
     2  21X,8A4,A3//19X,17H  S C : S S O R S,6X,7HM O D E / 5X,
     3  20HNATURAL  ROOT  ROTOR,4X,19HMAXIMUM   NUMBER OF,5X,3HMAX /
     4  6X,4HFREQ,4X,4HCOLL,3X,3HRPM,4X,9HAMPLITUDE,4X,5HNODES,4X,
     5  10HDEFLECTION /5X,4H/REV,5X,3HDEG,33X,10HANGLE--DEG  )
      LINES=0
      DO 160 IST=1,IRCOL
      IF(IST6(IST).LT.IST5(IST))  GO TO 160
      LINES=LINES+1
```

```
      WRITE(6,902)
      DO 150 IB=1,IBOM
      IF(IB6(IST,IB).LT.IB5(IST,IB))  GO TO 150
      WRITE(6,902)
      LINES=LINES+1
      MA=IB6(IST,IB)-IB5(IST,IB)
      IF(LINES.EQ.2.OR.LINES+MA.LE.50)  GO TO 120
      NPG=NPG+1
      WRITE(6,907) NPG,CDATE,ND,NAME,ITLE1,           ITLE2
      WRITE(6,903)
      LINES=2
  120 LINES=LINES+MA
      MA=IB5(IST,IB)
      MB=IB6(IST,IB)
      DO 145 I=MA,MB
      WRITE(6,902)
      SOMNA3(I  )=SOMNA3(I  )/DBOM(IB)
      IP = IP3(I)
      IN = INO3(I)
  140 WRITE(6,904) SOMNA3(I),   RCOLL(IST), DBOM(IB), (PLNE(J,IP),
     *J=1,2), (COFS(K,IN)  ,K  =1,2), DEG3(I)
  145 SOMNA3(I  )=SOMNA3(I  )*DBOM(IB)
  150 CONTINUE
  160 CONTINUE
      CALL TIMEX(TU,TT,TL)
      ET=60.*TT
      WRITE(6,906)  ET
  906 FORMAT ( 9HORUN TIME ,F8.2 ,8H SECONDS  )
      RETURN
      END
```

OS/360 FORTRAN H

```
    OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
              SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
      SUBROUTINE XYPLOT (Y,X,N,NR,ISCALE,M,IPRNT,TITLE)
C     X , Y      INPUT ARRAYS TO CROSS PLOT
C     N          NUMBER OF POINTS TO PLOT
C     NR         ALPHABET CYCLE KEY: CYCLES THRU FIRST NR LETTERS
C     ISCALE      = 0 MEANS PLOT X AND Y ON SAME SCALE
C                NOT = 0 MEANS USE BEST SCALE FOR EACH VARIABLE
C     M          BLOCK NUMBER TO BE FILLED BY THIS CALL (4 BLOCKS TOTAL)
C     IPRNT       = 1 MEANS TO PRINT THE WHOLE PAGE OF 4 PLOTS
C                NOT = 1 MEANS TO RETURN WITHOUT PRINTING
C     TITLE      24 ALPHAMERIC CHARACTERS DESCRIBING PLOT VARIABLES
       LOGICAL*1 TITLE,HEAD,NSCL,NEXP,NSIGN,BLOCK,ALP,BLANK,ONE,MINUS
      DIMENSION  TITLE(1),HEAD(36),NSCL(3),NEXP(10),NSIGN(2)
      DIMENSION  BLOCK(60,131),ALP(27)
      DIMENSION X( 1),Y( 1),SCALE(2),IXZ(4),IYZ(4)
      DATA HEAD /' ',' ','S','C','A','L','E','S',':',' ',' ','V','E',
     1    'R','T','.','.',2*' ','.','.','E',4*' ','H','O','R', 'I','Z','.',
     2      2*' ','.','.','E',2*' ' /
      DATA NSCL /'1','2','5'/, NEXP /'0','1','2','3','4','5','6','7',
     1            '8','9'     /,NSIGN /'+','-'/
C     DATA ALP/'A','B','C','D','E','F','G','H','I','J','K','L','M',
      DATA ALP/'B','C','T','D','E','F','G','H','I','J','K','L','M',
     *    'N','O','P','Q','R','S','T','U','V','W','X','Y','Z',' ' /
     *  ,MINUS /'-'/,  ONE /'I'/
     *  ,IYZ/ 2,34,2,34/ ,IXZ/ 1,1,69,69 /
      IF(IPRNT .LT. 0) GO TO 40
      IF(M.NE.1) GO TO 30
      BLANK = ALP(27)
      DO 300  I =1,60
      DO 300  J =1,131
  300 BLOCK(I,J) = BLANK
   30 CONTINUE
      CALL MINMAX (X,XMAX,XMIN,N,6.1,SX,JX,KX)
      CALL MINMAX (Y,YMAX,YMIN,N,4.33333,SY,JY,KY)
      IF(ISCALE .NE. 0) GO TO 20
      IF(SY .GT. SX) GO TO 10
      SY = SX
      JY = JX
      KY = KX
      GO TO 20
   10 SX = SY
      JX = JY
      KX = KY
   20 CONTINUE
      SCALEX = 10. / SX
      SCALEY =  6. / SY
      IZERO = -XMIN *SCALEX +0.5
      JZERO = -YMIN *SCALEY +0.5
      IZERO = IZERO +IXZ(M)
      JZERO = JZERO +IYZ(M)
      DO 100 K=1,62
      KIXZ = K+IXZ(M)
      BLOCK(JZERO,KIXZ) = MINUS
      IF(K.GT.27) GO TO 100
      KIYZ = K+IYZ(M) -2
      BLOCK(KIYZ,IZERO) = ONE
  100 CONTINUE
```

```
      L = 1                                                             XYPL0570
      DO 200 K=1,N                                                      XYPL0580
      I = IZERO +X(K)*SCALEX +0.5                                       XYPL0590
      J = JZERO +Y(K) *SCALEY +0.5                                      XYPL0600
      BLOCK(J,I) = ALP(L)                                               XYPL0610
      L = L+1                                                           XYPL0620
      IF(L.GT.NR) L=1                                                   XYPL0630
  200 CONTINUE                                                          XYPL0640
C     FILL IN NUMBERS IN HEADING                                        XYPL0650
      HEAD(18) = NSCL(KY)                                               XYPL0660
      HEAD(32) = NSCL(KX)                                               XYPL0670
      NS = 1                                                            XYPL0680
      IF(JY .LT. 0) NS =2                                               XYPL0690
      HEAD(21) = NSIGN(NS)                                              XYPL0700
      NS = 1                                                            XYPL0710
      IF(JX .LT. 0) NS =2                                               XYPL0720
      HEAD(35) = NSIGN(NS)                                              XYPL0730
      NS =IABS(JY) +1                                                   XYPL0740
      HEAD(22) = NEXP(NS)                                               XYPL0750
      NS =IABS(JX) +1                                                   XYPL0760
      HEAD(36) = NEXP(NS)                                               XYPL0770
C     PUT HEADING INTO BLOCK                                            XYPL0780
      J = IYZ(M)-1                                                      XYPL0790
      IS = IXZ(M) +1                                                    XYPL0800
      DO 400 K=1,24                                                     XYPL0810
      BLOCK(J,IS+K) = TITLE(K)                                          XYPL0820
  400 CONTINUE                                                          XYPL0830
      IS = IS +24                                                       XYPL0840
      DO 500 K=1,36                                                     XYPL0850
      BLOCK(J,IS+K) = HEAD(K)                                           XYPL0860
  500 CONTINUE                                                          XYPL0870
   40 IF(IPRNT .EQ. 0) RETURN                                           XYPL0880
         WRITE (6,1) ((BLOCK(J,I),I=1,130),J=1,60)                      XYPL0890
    1 FORMAT ('1'/(' ' 130A1 ) )                                        XYPL0900
      WRITE (6,2)                                                       XYPL0910
    2 FORMAT ('0  B AND C ARE SCALED TO 1 INCH; T IS SCALED TO 10 DEG.')XYPL0920
      RETURN                                                            XYPL0930
      END                                                               XYPL0940
```